of such descendants, other persons are eligible

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ANIMAL CHEMISTRY,

WITH REFERENCE TO THE

PHYSIOLOGY AND PATHOLOGY OF MAN

BY

Johann

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CHEMISTRY OF MAN.

CHAPTER III.

THE SECRETIONS OF THE CHYLOPOIETIC VISCERA, AND THE THEORY OF DIGESTION.

The Saliva.

The saliva is a peculiar fluid, secreted by the parotid, submaxillary, and sublingual glands, and conveyed from them by certain ducts into the cavity of the mouth, where it becomes mixed with the buccal mucus. It may, however, be obtained in a state of purity by collecting it as it flows from one of the ducts. The following observations respecting the secretion of the saliva were made by Mitscherlich,[1] on a person with a salivary fistula, in whom the saliva could be collected directly from Steno's duct. He found that there was no flow of saliva while the muscles of mastication and of the tongue were in a state of perfect repose, and all nervous excitement avoided. He likewise observed that, during the acts of eating and drinking, (especially at the commencement,) the secretion was abundant, being proportionate to the stimulating nature of the food and to the degree it was masticated. From two to three ounces of saliva were collected from one of the parotid glands in the course of twenty-four hours. It is usually supposed that about ten or twelve ounces of saliva are secreted daily, but accurate observations are still required on this subject.

Human saliva is a rather opalescent, viscid, colourless fluid;

[1] Rust's Magaz. vol. 40.

when collected and allowed to rest in a cylindrical glass, it is observed to yield a deposit of epithelium-scales and mucus-corpuscles, while the supernatant fluid remains clear. When perfectly normal, its reaction is alkaline; it is devoid of taste and odour, and, when observed under the microscope, is seen to contain peculiar corpuscles, which differ very slightly in their form from tumid mucus-corpuscles. The appearance presented by human saliva taken from the mouth, when examined under the microscope, is depicted in fig. 13. I have always observed the cells (*a*) in the saliva; they appear to consist of swollen salivary corpuscles. The salivary corpuscles are represented in (*b*); (*c*) represents epithelium-scales; and (*d*) fat-vesicles. Membranous shreds are sometimes observed, apparently fragments of injured epithelium-scales.

The amount of solid residue in the saliva is very small; it is composed of fat, ptyalin, water-extract, spirit-extract, a little albumen, certain salts, and a trace of sulphocyanogen. The presence of the last constituent was first noticed by Treviranus; it has since been detected by Gmelin and Tiedemann, and other chemists.[1]

The salts of human saliva are, according to Mitscherlich, chloride of calcium, lactates of soda and potash, soda either free or combined with mucus, phosphate of lime, and silica: according to Gmelin and Tiedemann, they consist of alkaline carbonates, phosphates, muriates, and traces of sulphates, toge-

[1] The occurrence of this substance in the saliva is equally interesting in a physiological and chemical point of view; and it would be very desirable to establish its presence in an unquestionable manner by experiments on a large quantity of saliva. Gmelin and Tiedemann (Die Verdauung nach Versuchen, vol. i, p. 9) formed an alcoholic extract of saliva, and distilled the residue, after mixing it with phosphoric acid. The fluid obtained by this distillation reddened litmus paper, after some days evolved an odour of prussic acid, yielded a deep yellow-red colour on the addition of perchloride of iron, and precipitates on the addition of nitrate of silver and nitrate of peroxide of mercury. On the addition of sulphate of iron and sulphate of copper to a portion of the distilled fluid, a white precipitate was thrown down, which communicated a red colour to an acid solution of perchloride of iron. The clear chlorine-solution, obtained by mixing chlorate of potash, hydrochloric acid, and chloride of barium, was rendered turbid when digested with a portion of the distilled fluid, and there was a gradual deposition of sulphate of baryta, the sulphuric acid being obtained at the expense of the hydrosulphocyanic acid. Gmelin and Tiedemann observed the reaction indicating the presence of sulphocyanogen in the saliva of the sheep, and I have noticed it in the saliva of the horse.

ther with the phosphates and carbonates of lime and magnesia. According to Hünefeld, ammoniacal salts are also present. On evaporating the saliva, we obtain a brown residue, which evolves a rather agreeable odour, resembling that of toasted bread.

In certain pathological states the saliva contains other substances besides those already enumerated: thus, in one case of morbid saliva I detected free acetic acid, and in another I found a considerable quantity of a substance resembling casein.

The albumen contained in the saliva is indicated by the turbidity produced on the application of heat; and after the removal of the coagulated albumen by filtration, the presence of the various extractive matters may be shown by the precipitates thrown down by acetate of lead, bichloride of mercury, and tannin; the casein may be indicated by the addition of acetic acid; ptyalin, and probably casein, by the addition of alcohol to clear and somewhat concentrated saliva; and sulphocyanogen, by the redness produced on the addition of perchloride of iron.

With a view to separate the constituents of the saliva I evaporated a known quantity to dryness, and thus determined the water. I then treated the residue with ether, for the purpose of extracting the fat; and with water, in order to take up the ptyalin, extractive matters, and salts. The insoluble residue that had resisted the action of ether and water, consisted of albumen and mucus. Another portion of the saliva was decanted from its precipitate, evaporated to a small residue, and the ptyalin, with a trace of extractive matter, precipitated by alcohol. When the saliva contains a caseous matter, (which I have observed in large quantity in the saliva of the horse,) the precipitate of ptyalin and casein produced by the alcohol must be dissolved in water, and the casein then thrown down by the careful addition of acetic acid. In this case, a portion of the casein precipitated by the alcohol usually remains undissolved by the water. I have detected free acetic acid in the saliva discharged during salivation. In order to determine its quantity, the saliva must be accurately neutralized by a solution of carbonate of potash of known strength; from the amount of the alkaline solution required, the quantity of acetic acid can be calculated. If, in addition to acetic acid, free lactic acid is likewise present, the residue of the saliva, after evaporation,

when dissolved in water, will still indicate an acid reaction, because lactic acid differs from acetic acid in not being volatilized at the ordinary temperature used for evaporating animal fluids. In order to determine the amount of free soda in the saliva, the dried residue must be extracted with alcohol; the free soda (which is left in the residue) must be saturated with acetic acid, the resulting acetate of soda extracted with alcohol, evaporated, and, by incineration, reduced to carbonate of soda.

An analysis of my own saliva yielded the following results. It contained, in 1000 parts:

	Analysis 58.
Water	991·225
Solid constituents	8·775
Fat containing cholesterin	·525
Ptyalin with extractive matter	4·375
Extractive matter and salts	2·450
Albumen, mucus, and cells	1·400

Berzelius[1] found, in 1000 parts of human saliva:

Water	992·9
Ptyalin	2·9
Mucus	1·4
Extract of flesh with alkaline lactates	·9
Chloride of sodium	1·7
Soda	·2

According to the analyses of Tiedemann and Gmelin, 1000 parts of human saliva contain from 9 to 11·4, or even 11·9 of solid constituents, consisting in 100 parts, of phosphorized fat, extract of flesh, chloride of potassium, lactate of potash, and sulphocyanide of potassium, 31·25;—animal matter with traces of alkaline sulphates and chlorides, 1·25;—ptyalin, with alkaline phosphates, chloride of sodium, and traces of alkaline sulphates, 20·00;—mucus and a little albumen, with alkaline phosphates and carbonates, 40·00. This solid residue yielded on incineration 21·9% of inorganic constituents, 17·8 of which were soluble, and 4·1 insoluble in water. Mitscherlich found that 1000 parts of human saliva yielded from 14·7 to 16·3 of solid residue, of which 34% were insoluble both in water and in alcohol, 42% soluble in water but not in alcohol of ·800, and 24% soluble in water and in alcohol. These proportions varied, however, in different analyses.

[1] Thierchemie, p. 219.

The inorganic constituents in 1000 parts of saliva are, according to Mitscherlich, chloride of calcium, 1·8; lactate of potash, ·95; lactate of soda, ·24; soda, probably combined with mucus, 1·64; phosphate of lime, ·17; silica, ·15.

[According to Dr. Wright, pure saliva is a limpid fluid, having a faint blue tinge, and a slight degree of viscidity. It is perfectly uniform in consistence, and unobscured by frothiness or flocculi. It possesses a faint sickly odour *sui generis*, due to its constituent, ptyalin: this odour is strengthened by heat and by most acids, but alkalies diminish and destroy it.

The saliva even of healthy people varies considerably in its specific gravity. It is always denser after a meal than during fasting; and generally denser in an evening than in a morning. But the converse is usually the rule with dyspeptics. Dr. Wright found that animal (especially fatty) diet, and alcoholic stimulants, have a tendency to thicken the saliva; oysters, and vegetable diet, he says, produce an opposite effect. He states, as the result of many trials and observations, that healthy saliva is mostly of a sp. gr. of 1007·9. When above 1010·0 or below 1003·0, the secretion may be considered to be morbid. Healthy saliva, he affirms, is either alkaline or neutral, generally the former. If saliva be heated, it not uncommonly acquires an acidity in a few minutes, but this chiefly happens to neutral saliva.

Dr. Wright believes in the existence of the principle called ptyalin, though he separates it from saliva by a new process. This process is "to pass saliva through ordinary filtering paper, and, after filtration shall have been completed, to exhaust the residue with sulphuric ether; the ethereal solution contains a fatty acid and ptyalin.[1] It is to be allowed to evaporate spontaneously, and the residue left by evaporation is to be placed upon a filter and acted upon by distilled water, which dissolves the ptyalin and leaves the fatty acid. If the aqueous solution be carefully evaporated to dryness, the "salivary matter will be obtained in a pure state." "Ptyalin," he says, "as thus prepared, is a yellowish-white, adhesive, and nearly solid matter, neither acid nor alkaline, readily soluble in ether, alcohol, and

[1] A reference to vol. i, p. 24, will show that Wright's ptyalin differs in several respects from the ptyalin described by Simon. In truth, little is known regarding this constituent.

essential oils, but more sparingly soluble in water. It alone possesses the characteristic odour of saliva; it is unaffected by galvanism and by most of the reagents which coagulate albumen. It is abundantly precipitated by sub-acetate of lead and nitrate of silver; feebly so by acetate and nitrate of lead, and tincture of galls; uninfluenced by bichloride of mercury and strong acids; the latter considerably heighten its proper odour and impair its solubility, whilst alkalies render it more soluble, and give it the smell of mucus. Moderate heat and oxygen gas also increase its odour, but a more intense heat or cold diminishes or entirely destroys it. At a suitable temperature, ptyalin may be preserved for any length of time without risk of decomposition. The salivary fluid from which ptyalin has been removed, possesses a sickly mucous smell, decomposes much sooner than ordinary saliva, and, in the process of decay, invariably evolves ammonia. If the fluid be heated, the mucous smell will be increased until the evaporation shall have been continued nearly to dryness, when a slight salivary odour may be recognized, due to a portion of ptyalin being liberated from the mucus with which it was previously in combination."

Dr. Wright says that sulphocyanogen is an invariable constituent of healthy human saliva. He advises that it be sought for in the alcoholic extract of the residue left by the careful evaporation of the fluid, as the mucus, unless removed, offers considerable impediment to the action of reagents. The sulphocyanogen occurs in combination with potassium, the salt constituting generally from ·051 to ·098 of the secretion. "The proportion," he says, "is temporarily augmented by local stimulation of the salivary glands, as by smoking, chewing sialagogues, &c. It is also increased by the internal use of prussic acid and salts of cyanogen, and remarkably so by the use of sulphur."

Pure saliva absorbs a variable quantity of oxygen. Dr. Wright says, "I have known the quantity absorbed to exceed $2\frac{1}{4}$ times the bulk of the saliva; but I once met with an instance in which the healthy secretion did not absorb more than half its volume of oxygen. The difference is generally dependent upon the carbonic acid gas naturally contained in the saliva, the proportion of which gas to the secretion varies from one eighth to one twelfth in volume, though, in some particular

cases, it is much more abundant." He says that saliva, in its healthy state, contains also oxygen gas, which it can be made to evolve on the application of heat. This in some measure aids its digestive powers; for he found that saliva which had been exposed for some hours to an atmosphere of oxygen, converted a much greater quantity of starch into gum and sugar than other saliva which had not been so exposed. This statement, founded upon a great number of comparative experiments was made by Dr. Wright long before the apparently less correct observation of Liebig, that the saliva collects "bubbles of air" to assist the digestive function. In pure saliva there are no "bubbles of air;" the absorbed gases are carbonic acid and oxygen, the latter only contributing to the digestive properties of the fluid. As the result of numerous analyses, the process of which Dr. Wright has fully detailed, he gives the following as the constituents of the healthy secretion:[1]

Water	988·1
Ptyalin	1·8
Fatty acid	·5
Chlorides of sodium and potassium	1·4
Albumen with soda	·9
Phosphate of lime	·6
Albuminate of soda	·8
Lactates of potash and soda	·7
Sulphocyanide of potassium	·9
Soda	·5
Mucus, with ptyalin	2·6

L'Heretier has recorded the mean of ten analyses of the saliva of healthy persons, collected while fasting:

Water	986·5
Organic matter	12·6
Inorganic matter	·9

The salivary matter, or ptyalin, formed 2·5 of the 12·6 parts of organic matters.

In children, the amount of water is generally increased. As a mean of four analyses, he found:

[1] Der Speichel in physiologischer, diagnostischer, und therapeutischer Beziehung, p. 28, Wien, 1844. Dr. Wright's investigations first appeared in the Lancet.

Water	996·0
Organic matter	3·5
Inorganic matter	·5

The ptyalin amounted to only 1·1.

He was unable to detect any difference between the saliva of man and woman.

Enderlin has made numerous analyses of the ash left after the incineration of the saliva, and has always found it to have the same constituents. He considers that its alkaline reaction is due to the tribasic phosphate of soda ($3NaO, PO_5$) which retains the mucus and protein-compounds in solution. Enderlin observes that, independently of conclusions deduced from the ash, he has sought unsuccessfully, in a direct manner, for lactates in the saliva. On incinerating salivary mucus obtained by washing that constituent from a filter, the residue is found to consist of phosphate of lime, with traces of chloride of sodium and phosphate of soda, the same composition as the tartar that collects on the teeth.

A quantitative analysis of the ash from a large amount of saliva obtained from different persons, yielded the following results:

A. *Constituents soluble in water.*

Tribasic phosphate of soda ($3NaO, PO_5$)	28·122	92·387
Chlorides of sodium and potassium	61·930	
Sulphate of soda	2·315	

B. *Constituents insoluble in water.*

Phosphate of lime	5·509]
„ magnesia	
„ peroxide of iron	

Very little is known with certainty regarding the part taken by the saliva in the process of digestion. Spallanzani fancied that he had observed that food inclosed in tubes pierced with numerous apertures, and moistened by the saliva, was more rapidly digested than when simply moistened with water. Berzelius, however, found that the saliva exerts no greater solvent power than pure water, and Müller confirms his statement. Hünefeld, on the other hand, believes that the object of the saliva is to destroy the tenacity of the food, and he

thinks that it has the power of reducing fibrin to the condition of a viscid fluid.

[The services which the saliva performs in the animal economy are classified by Dr. Wright as follow:

Active.—1. To stimulate the stomach and excite it to activity by contact. 2. To aid the digestion of food by a specific action upon the food itself. 3. To neutralize any undue acidity in the stomach by supplying a proportionate alkali.

Passive.—1. To assist the sense of taste. 2. To favour the expression of the voice. 3. To clear the mucous membrane of the mouth, and to moderate thirst.

Mialhe[1] has recently announced the discovery of an active principle in the saliva analogous in its physical and chemical characters to diastase. It is solid, white or greyish-white, amorphous, insoluble in alcohol, but soluble in water and spirit. The directions for obtaining it are the following: Filter saliva and treat it with five or six times its weight of absolute alcohol, adding it as long as any precipitate occurs. This animal diastase is insoluble, and falls in white flocks, which must be collected on a filter and dried. It forms about ·2% of the whole saliva.]

Leuchs[2] was the first who observed that saliva converts boiled starch into sugar.

Morbid Saliva.

The saliva becomes affected in various morbid conditions of the system, but the nature of the changes that it undergoes has not hitherto been sufficiently studied. Morbid saliva sometimes contains a free acid; this is most commonly lactic acid, but, in some cases, acetic acid is likewise present. The acid reaction may be at once detected by test paper; while normal saliva communicates a blue tint to red litmus paper, this, on the contrary, reddens blue paper. I have frequently seen the saliva acid in acute rheumatism, and in cases of sali-

[1] Lancette Française, 1845, April.
[2] Kastner's Archiv. 1831.

vation. According to Donné,[1] the saliva has an acid reaction in all cases of irritation and inflammation of the stomach, in pleuritis, encephalitis, intermittent fevers, acute rheumatism, uterine affections, and amenorrhœa. Brugnatelli[2] detected oxalic acid in the saliva of a phthisical patient. The secretion of saliva is sometimes increased to an extraordinary degree, constituting salivation; in such cases, the chemical characters of the saliva are also more or less affected. In a specimen of saliva forwarded to me for examination, which was obtained from a patient who had just terminated a course of mercury of some weeks' duration, I observed an acid reaction arising from the presence of free acetic acid. It was very viscid, of a yellow colour, and possessed a sickly, disagreeable, acid smell. It contained no mercury. After evaporation to dryness, all the acid reaction had disappeared: thus showing that it contained no free lactic acid. This saliva contained a very large quantity of semifluid fat, a considerable amount of albumen, and traces of caseous matter. Under the microscope, an immense number of fat-vesicles were seen, some epithelium-cells, and a very few partially-destroyed saliva-corpuscles. 1000 parts of this saliva were composed of:

	Analysis 59.
Water	974·12
Solid constituents . . .	25·88
Yellow viscid fat . . .	6·94
Ptyalin with extractive matter and traces of casein	3·60
Alcohol-extract with salts . .	7·57
Albumen	7·77

The salts consisted of a largely preponderating amount of the chlorides of sodium and potassium, associated with the lactates of soda and potash, and with a small quantity of the earthy phosphates. On contrasting this saliva with the normal fluid, we are struck with its large amount of solid constituents, arising not from any increase of the ptyalin, but of the fat, the extractive matters, the albumen, and the salts.

[L'Heretier gives the mean of three analyses of this secretion during mercurial ptyalism. He found:

[1] Arch. Génér. de Méd. 1835, May.

[2] Stark. Allgemeine Pathologie, p. 1074.

Water	970·0	in place of 986·5
Organic matters	28·6	12·6
Inorganic matters	1·1	1·9

The mean amount of ptyalin was 2·6, or very nearly the normal quantity. He attributes the large amount of organic matter to the increased quantity of mucus secreted by the buccal membrane.

Dr. Wright also found that the saliva of mercurial ptyalism contained an unusual amount of mucus. It consisted of:

Water		988·7
Ptyalin		1·9
Fatty acid		·4
Albumen with soda, and Albuminate of soda		·6
Mucus with a trace of ptyalin		3·8
Lactates Phosphates Muriates Hydrosulphocyanates	Potash Soda Lime	2·4

He could not detect the slightest trace of mercury in it.]

Gmelin[1] has examined saliva discharged in consequence of salivation produced by mercurial inunction. In one case it was brown and turbid, and contained a large quantity of fat but not much albumen; in another instance it presented a yellow tint; it contained a large quantity of yellow fat, and when heated, gave no perceptible indication of coagulation. In both cases, but most decidedly in the latter, indications of mercury were obtained.[2] Thomson[3] found the saliva resulting

[1] Pogg. Ann. 41, p. 438.

[2] Gmelin employed Smithson's method for the detection of the mercury. A large quantity of saliva was treated with nitric acid, and evaporated; the residue was digested with nitric acid and dissolved in water; and, after the removal of fat by filtration, a stream of sulphuretted hydrogen was passed through it. The precipitate obtained by this process contains sulphuret of mercury; it must be collected, digested in nitro-muriatic acid, evaporated, dissolved in dilute hydrochloric acid, and a bit of gold-leaf enveloped in tin-foil, or encircled by iron wire, suspended in the fluid. The gold is tarnished if mercury is present. No tin-foil should be used that has not been itself tested for mercury. In place of the gold-leaf I have employed the blade of a knife with advantage.

[3] Annals of Philosophy, vol. vi, p. 397.

from the administration of mercury, turbid; it deposited flocculi of coagulated albumen. It was not precipitable by tannic acid, had a specific gravity of 1003·8, and contained, coagulated albumen, 2·57; mucus, 3·67; chloride of sodium, ·9; water, 992·8. Bostock analysed the saliva of a man who was secreting about two quarts daily in consequence of mercurial salivation. It was of a clear brown colour, neutral, viscid, but not stringy, and barely transparent. It became clear, however, after the deposition of the minute flocculi suspended in it; the application of heat, and also the addition of corrosive sublimate, gave indications of the presence of albumen. It yielded 2% of dried residue. After the discontinuance of the mercury, the saliva was found to be less transparent; it reddened litmus paper, contained more albumen, and more solid constituents generally. Vogel[1] analysed the saliva of a man with spontaneous salivation; it contained 991·2 parts of water; 4·4 of ptyalin, osmazome, fat, and albumen; and 4·4 of salts of soda, potash, and lime; hence, in respect to the amount of solid constituents and ptyalin, this saliva did not differ very much from the normal standard. Mitscherlich also found that, in the salivary flow excited by nervous irritation, the amount of the solid constituents was not increased, that the ptyalin and sulphocyanogen were even below the normal standard, while, on the other hand, the extractive matters were somewhat increased. A similar observation has been made by Guibourt.

I examined the saliva of a patient suffering from an inflammatory affection of the pancreas. It was discharged from the mouth in large quantity; it was a clear, viscid fluid, mixed with mucus, alkaline in its reaction, and exhibiting, under the microscope, mucus-corpuscles, numerous oil-vesicles, epithelium-cells, and membranous shreds: its specific gravity was 1005; and 1000 parts yielded only ten of solid residue, which, in addition to mucus, and a very small quantity of albumen, consisted principally of an extractive matter which developed an aromatic odour on the application of heat, of fat, certain salts, and a little ptyalin.

[1] Lehrbuch der Physiologie, von R. Wagner, p. 212.

[L'Heretier observes that, in chlorosis, the amount of water increases in proportion to the progress of the disorder. An analysis of the saliva in this disease is given in page 299 of his Pathological Chemistry.

In dropsy, with albuminous urine, the saliva contained:

Water . . .	985·9
Organic matter . . .	13·6
Inorganic matter . .	·5

In most inflammatory affections, the amount of water is diminished. The following numbers express the mean results of six analyses in cases of inflammatory fever, pneumonia, and erysipelas:

Water . . .	968·9
Organic matters . .	30·0
Inorganic matters . .	1·1

The mean amount of ptyalin was 3·6; the ordinary amount, according to L'Heretier, being 2·5.

The three following forms of morbid saliva have been analysed by Dr. Wright:

Fatty saliva.

Water	987·4
Ptyalin	·7
Adventitious fatty matter and fatty acid .	3·9
Albumen with soda, and albuminate of soda . .	1·5
Sulphocyanide of potassium . .	a trace
Mucus	2·4
Lactates . Muriates . Phosphates . } Potash Soda . Lime .	1·8

Sweet saliva.

Water	986·9
Ptyalin	·3
Fatty acid	·2
Muco-saccharine matter . . .	5·6
Albumen with soda, and albuminate of soda . .	·4

Sulphocyanogen			a trace
Mucus with a trace of ptyalin			2·6
Lactates	Potash		
Muriates	Soda		1·9
Phosphates	Lime		

Bilious saliva.

Water			986·7
Ptyalin			·5
Fatty matter and fatty acid			1·3
Biliary matter			3·2
Cholesterin			·4
Albumen with soda, and albuminate of soda			1·9
Mucus			1·6
Carbonates	Potash		
Muriates	Soda		2·3]
Phosphates	Lime		

Saliva of animals.

I have analysed the saliva of a horse suffering from ozæna. Professor Hertwig kindly assisted me in exposing Steno's duct; and, in the course of eight hours, (during which time the horse was feeding,) about five ounces of saliva were collected from the opened duct. The fluid was viscid, of a faintly yellow colour, devoid of odour, alkaline in its reaction, and possessed a specific gravity of 1006. (Schultz[1] collected in a similar manner 55 ounces 7 drachms of saliva from a horse in the course of twenty-four hours.) After some time, the saliva deposited a white sediment, consisting of irregular membranous shreds and saliva-corpuscles. On the application of heat it became turbid. A copious precipitate was thrown down on the addition of acetic, dilute sulphuric, or lactic acid; and on evaporation it became covered with a film of coagulated casein. Perchloride of iron produced a vivid red colour, and a slight precipitate. It contained a larger amount of solid constituents than human saliva, and a very considerable quantity of casein, part of which coagulated on evaporation, and part was thrown down by acetic acid; in this manner it was sepa-

[1] De Alimentor. concoctione. Berol. 1834.

rated from the ptyalin. 1000 parts of this saliva were composed of:

	Analysis 60.
Water	982·000
Solid constituents	18·000
Fat containing cholesterin	·120
Ptyalin with extractive matters	4·442
Casein	5·422
Albumen	·601
Extractive matters and salts	7·178

Saliva of the dog.

The saliva of a healthy dog was collected by exposing Steno's duct, and examined by Gmelin and Tiedemann. It was rather turbid, of a pale yellowish-white colour, thick, capable of being drawn out in threads like albumen, alkaline in its reaction, and 1000 parts left, on evaporation, a solid residue of 25·8, consisting of a little extractive matter soluble in alcohol, an average quantity of ptyalin, mucus, a very large amount of chloride of sodium, together with alkaline carbonates, acetates, sulphates, and phosphates, and a little phosphate and carbonate of lime.

Saliva of the sheep.

Gmelin and Tiedemann succeeded in collecting between three and four ounces of saliva in the course of fifteen hours from the stenonian duct of a sheep. It was of a reddish tint, in consequence of being mixed with a little blood, perfectly fluid, faintly alkaline, and of a slightly saline taste. 1000 parts of the saliva contained:

Water	989·0
Extract of flesh, an organic matter with which chloride of sodium crystallized in octohedra, chloride of sodium, and a little sulphocyanide of sodium	1·1
A little ptyalin, with a good deal of phosphate and carbonate of soda, and chloride of sodium	8·2
Mucus or albumen, with a little phosphate and carbonate of potash	·5

The Pancreatic Fluid.

The most accurate analysis of the pancreatic juice is that of Tiedemann and Gmelin.[1] Earlier observers, as, for instance, De la Boë, De Graf, and others, had shown that it is an acid, clear, rather viscid fluid, possessed of a saline or acid-saline taste. Wepfer, Pechlin, and Brunner, on the other hand, had described it as turbid, of a whitish colour, not acid, but having a saltish taste, somewhat like the lymph. Mayer[2] described the pancreatic juice of a cat as transparent, viscid, decidedly alkaline, and containing albumen, chloride of sodium, and a peculiar animal matter. Magendie found it alkaline and albuminous in a dog, and in birds it contained so large an amount of albumen as to coagulate on the application of heat.

Tiedemann and Gmelin cut down upon the pancreatic duct of a strong well-fed dog, and, in the course of four hours, collected about 155 grains of the fluid secretion. The portion that was first collected was turbid, and somewhat red, probably in consequence of the presence of a little blood. This was placed aside. The subsequent portion had a blueish-white tint; could be drawn out in threads like dilute albumen, had a faintly saline taste, and an alkaline reaction. 1000 parts left 87 of solid residue. The red portion first collected has a faintly acid reaction. The principal constituents were extractive matters, chloride of sodium, albumen, and a sort of modified casein.

The pancreatic juice of a sheep was found by Gmelin and Tiedemann to be clear, slightly acid, and of a faintly saline taste. 1000 parts left 36 of solid residue, consisting of the same ingredients as in the dog. In this instance, also, the portion that escaped during the latter part of the experiment was alkaline, and was richer in solid constituents than the fluid that escaped earlier; it contained 51·9 of solid constituents in 1000 parts.

The following is the result of their analyses:

	In the dog.	In the sheep.
Water	917·2	963·5
Extractive matters and salts soluble in alcohol	36·8	15·5
Caseous matter and soda-salts soluble in water	15·3	2·8
Albumen and salts . . .	35·5	22·4

[1] Op. cit. vol. i. p. 25. [2] Deutsch. Arch. für die Physiologie, vol. iii, p. 170.

The alcohol-extract of the pancreatic juice of the dog yielded a very singular reaction. On the addition of a little solution of chlorine to the dissolved alcohol-extract, a vivid rose-red tint was produced, and, in the course of twelve hours, there was a precipitation of delicate violet-coloured flocculi. The colour was immediately destroyed by the addition of an excess of chlorine. An attempt to isolate this colouring matter proved unsuccessful.

Leuret and Lassaigne have analysed the pancreatic juice of a horse, and the result of their investigation is, that it is almost identical in its composition with human saliva. This statement is so much at variance with the results obtained by Tiedemann and Gmelin, that we must conclude that Leuret and Lassaigne were not sufficiently careful in their investigation.

We are still unable to state with any degree of certainty what part the pancreatic fluid performs in the process of digestion. There can be no doubt that when the pancreas is diseased, the pancreatic fluid must be also affected, but we are perfectly in the dark as to the nature of those changes.

The Bile.

Bilin and urea can hardly be regarded as simultaneous products of the metamorphic action of the blood; for while I have detected small quantities of urea in the blood of a healthy calf, I have never been able to recognize the least trace of bilin or of bile-pigment. Hence, while urea is produced not only in the kidneys but in other parts of the system, bilin seems to be produced and secreted only in the liver.

The bile is a very complicated fluid. According to the latest researches of Berzelius, it contains bilin; cholepyrrhin (or biliphæin); biliverdin; mucus; cholesterin; oleate, margarate, and stearate of soda; chloride of sodium; sulphate, phosphate, and lactate of soda; and phosphate of lime.

Gmelin and Tiedemann, as well as Frommherz, mention casein and ptyalin, and the carbonates and sulphates of soda and lime, among the constituents of the bile.

A perfect analysis of bile would be a subject of extreme labour and difficulty, and we must, therefore, confine our attention to its most important constituents. Let us suppose that

it was required to ascertain the amount of bilin, bilifellinic acid, and cholesterin, in a specimen of bile; the fluid must be first evaporated to dryness, and the amount of water thus estimated; the residue must be repeatedly extracted with ether, the ethereal solution evaporated to dryness, and its residue, consisting of cholesterin and fluid fat, thoroughly washed with cold and not too strong alcohol, which dissolves the greater portion of the fluid fat. It must then be digested with hot alcohol of 0·83; and as this solution cools, the cholesterin separates in crystals. After the removal of the fat, the residue is treated with anhydrous alcohol, which takes up bilin, bilifellinic acid, and biliverdin. The filtered alcoholic solution is then treated with a solution of chloride of barium, as long as a dark green precipitate falls; and afterwards with baryta water, *guttatim*, as long as it causes any turbidity; it is then filtered, the excess of baryta thrown down by a stream of carbonic acid, the carbonate of baryta removed by filtration, and the solution evaporated to perfect dryness. The residue is dissolved in anhydrous alcohol, all the bases are thrown down from the alcoholic solution by sulphuric acid dissolved in strong spirit, and then, after filtration, the solution is mixed with moist, pure carbonate of lead, and the greater part of the alcohol distilled. The fluid remaining in the retort is removed by filtration from the insoluble portion, the lead removed by sulphuretted hydrogen, and the fluid evaporated. The residue, after being extracted with ether, leaves pure bilin mixed with a certain amount of fellinic and cholinic acids, which must be separated with oxide of lead. We then obtain pure bilin and bilifellinic acid combined with oxide of lead.

An accurate quantitative determination of the most important ingredients of the bile, although difficult, is by no means impracticable. It is, however, very uncertain whether the result of the analysis would afford any insight into the true character of that changeable secretion. From the latest researches of Berzelius, it appears that the bilin is so unstable a compound, that it is hardly possible to obtain bile in the condition in which it is secreted by the liver, or as it exists in the gall-bladder: for when bile is left to itself, and much more when it is acted on by heat and other more or less energetic agents, the bilin undergoes a series of metamorphoses by which fellinic, cholinic,

and very probably also cholanic and fellanic acids are produced. The biliary secretion, as it exists in the liver, may be regarded as pure bilin mixed with biliverdin and fats; the bilin probably commences its metamorphoses in the gall-bladder, and continues them in its passage onwards into the intestinal canal. If fellinic and cholinic acids are formed in the gall-bladder, then the presence of the two bilifellinic acids in fresh bile may be at once assumed, since they are only to be regarded as combinations of the former with different proportions of bilin. It is not by any means probable that cholic acid exists in fresh bile, and the presence of dyslysin and taurin may be positively denied; consequently, the biliary resin, the mixture of fellinic and cholinic acids and dyslysin does not pre-exist in the bile.

Berzelius and Thénard have made quantitative analyses of healthy human bile: they found, in 1000 parts:

	Berzelius.		*Thénard.*
Water . . .	907·4	Water . . .	909·0
Bilin, fellinic acid, &c. .	80·0	Yellow and very bitter resin	37·3
Mucus dissolved in a free alkali	3·0	Brown pigment and mucus	1·8—9·0
Free alkali and the ordinary salts	9·6	Albumen . .	38·2
		Soda holding the resin in solution . .	5·1
		Salts of potash and soda, and peroxide of iron .	4·1

According to Gmelin and Tiedemann, human bile contains biliary sugar, brown pigment, a little biliary resin, cholesterin, ptyalin, mucus, oleic acid, and salts.

[In the year 1837, Demarçay announced that the bile consisted essentially of an organic acid combined with soda. He termed this acid *choleic*, and obtained it in the following manner: Bile from which the mucus had been precipitated by alcohol was evaporated on the water-bath, and ten parts of the dried residue were dissolved in 100 of water, to which ten of hydrochloric acid had been added. Allowing evaporation at a moderate temperature to proceed, it was observed that a dark green oil collected on the surface, while, at the same time, the fluid became turbid. On removing the oil, and allowing the fluid to rest for some time, it gradually became clear, with the precipitation of a green deposit. This dark green bitter precipitate is

Demarçay's choleic acid, and is regarded by him as constituting nine tenths of the solid constituents of the bile. It is still mixed with margaric acid, cholesterin, pigment, &c. After the removal of these impurities, it is described by Demarçay as a yellow, spongy, pulverulent matter, which rapidly absorbs oxygen from the atmosphere; very bitter, slightly soluble in ether, soluble in water, and very soluble in alcohol. Its solutions have an acid reaction, decompose carbonates, and form a peculiar class of salts with bases from which the choleic acid may be removed by acetic acid. Its composition is represented by the formula $C_{42}H_{36}NO_{12}$. The choleate of soda obtained by adding an alcoholic solution of soda to an alcoholic solution of choleic acid till there is an alkaline reaction, and then passing a current of carbonic acid through it to remove the excess of soda, possesses all the characters of bile; it yields, on evaporation, a brown resinous mass, and is soluble in water and in alcohol.

When choleic acid is boiled with hydrochloric acid, it yields ammonia, taurin,[1] and choloidic acid; the latter being insoluble, is deposited. (Compare this with page 46, vol. I.) Choloidic acid is solid, fusible, of a yellow colour, and bitter taste, insoluble in water, and soluble in alcohol. It combines with bases, neutralizing them, and forming salts which are soluble in alcohol. It contains no nitrogen, and its formula is $C_{72}H_{56}O_{12}$.

Dr. Kemp has communicated some experiments relative to the bile, tending to show that it is principally composed of a mere simple solution of a salt of soda, the acid of which differs from the choleic acid of Demarçay in several respects; he terms it bilic acid. Liebig has published a memoir based on Kemp's experiments, in which he arrives at very similar conclusions, but regards bilic acid as identical with the choleic acid of Demarçay and the bilifellinic acid of Berzelius.

Theyer and Schlosser have subsequently published an account of some new researches on the bile which were made in the Giessen laboratory, and confirm the accuracy of Liebig's previous conclusions.

In a recent essay on the bile, by Platner,[2] it is shown that

[1] It has been recently asserted by Redtenbacher that taurin contains 26§ of sulphur. Hence the formula C_4H_7NO (see vol. I. p. 47) fails to represent its true composition.

[2] Müller's Archiv, No. 2, 1844.

the bilic acid and acid bilate of soda may be procured in a crystalline state. In a subsequent communication by the same chemist, after correcting certain errors in his first paper, he proceeds to show that two distinct substances are met with in perfectly fresh bile: "I have been able," he observes, "to cause bile, which was evaporated in a water-bath, and freed from mucus and the greater part of its salts by repeated solution in alcohol, to crystallize immediately. For this purpose nothing further is necessary than to add ether repeatedly to as strong an alcoholic solution of the bile as possible, and then to set it aside in a cool place. The principal and most important constituent of the bile then crystallizes, in the same manner as in my former experiments; but $\frac{1}{8}-\frac{1}{4}$ of the bile used does not crystallize, but remains as a yellowish-brown syrup. I have not been able to succeed in separating this in any manner from the crystals; consequently, I can say nothing more concerning its nature. It is, however, evidently a different substance from the principal constituent of the bile, possibly a product of its decomposition. The decomposition of the bile begins even in the organism, and it is impossible to examine fresh bile which is not partly decomposed. The brown liquid appears to consist principally of biliary colouring matter. I must, however, remark that the crystals have also a slightly yellow tint. The principal constituent of bile is a compound of soda with a peculiar organic body, and this compound may be immediately procured from the bile without its undergoing any important alteration. Liebig called this compound bilate of soda; I have denominated it choline-soda. It does not appear to me sufficiently proved that the principal organic constituent of bile is positively an acid. It is possible that, like albumen, it may combine with acids as well as with bases. The most recent examinations of the bile by Berzelius would then be partly true. Further experiments must decide this. These, however, are peculiarly difficult, because, in separating the bile from soda, an acid body may undoubtedly be formed. From the above observation, it is further evident that the formula advanced by Liebig for bilic acid must be incorrect; for Kemp, Theyer, and Schlosser have not analysed the essential biliary ingredient in a perfectly pure state, but have always at the same time included the brown syrup.]

Morbid Bile.

Our knowledge of the changes that the bile undergoes in disease is still very superficial.

In persons suffering from dropsy, the bile is stated by Forget to be thinner, and, in persons with diseased liver, thicker, than in the normal state. I examined the contents of the gall-bladder of the woman with icterus, referred to in vol. I, p. 329. I only obtained a small quantity of viscid, dirty yellow fluid, from which alcohol precipitated mucus and albumen. The portion soluble in alcohol yielded, after evaporation, a small quantity of a viscid substance with a sweet rather than a bitter taste. Bizio[1] has analysed a remarkable specimen of bile taken from the gall-bladder of a man who died in a jaundiced condition. It was a fluid of a dark-red colour, thick, of a nauseous but not bitter taste, with an odour of putrid fish, and holding in suspension red and black particles. It contained fatty oil, 3·972; stearin, 8·613; green resin, 2·030; a yellow, non-nitrogenous, hard substance, soluble in alkalies, in cold hydrochloric acid, and in alcohol, 1·937; erythrogen, 4·157; dissolved hæmatin, 3·148; a gummy-saccharine extract with colouring matter, 1·978; soluble albumen, 7·282; fibrin, 11·348; phosphate of soda, 1·340; chloride of sodium, 0·984; phosphate of lime, 1·320; peroxide of iron, 0·532; water, 51·232.

[Scherer[2] analysed the bile of a man who died in a state of icterus. It was a thick fluid of a blackish green colour, and exhibited under the microscope a large number of pigment-cells. It contained in 1000 parts:

Water	859·6
Solid constituents	140·4
Bilin	48·6
Bilifellinic acid	30·5
Fat	8·6
Bile-pigment	44·3
Salts	8·0

Not a trace of cholesterin could be discovered in this bile,

[1] Brugnatelli Giorn. di Fisica, vol. xv, p. 455.

[2] Untersuchungen, &c. p. 103.

which Scherer regards as singular, although, according to Berzelius, it amounts to only ·0001% of healthy bile (in the ox), a quantity easily overlooked. The bile-pigment[1] in healthy bile is imponderable; its amount in this case, as well as that of the solid constituents generally, is enormous.]

Chevallier[2] found that the bile of a man with scirrhous pancreas, who died jaundiced, was of a pale greenish yellow colour, evolved a putrid odour, had an alkaline reaction, and a faint, slightly saline taste: it contained a yellow, semi-crystalline fat, green resinous matter, ptyalin, osmazome, soluble albumen, hydrosulphate of ammonia, and phosphate, sulphate, and hydrochlorate of soda. Chevallier found that the bile of a woman who died from pulmonary phthisis was of a brownish yellow colour, and yielded 2% of dried residue, of which 0·83 was biliary sugar. According to Chevreul, the bile in cases of phthisis contains very little fat. The bile of a woman who died from the effects of syphilis is described by Chevallier as of a dark green colour; it yielded 20 — 30% of dried residue, of which one third, or 0·94, was biliary sugar, with resinous and yellow matter.

Phœbus[3] found that, in persons who died from cholera, the gall-bladder was usually tolerably full, (sometimes to an excess,) and that the bile was rather dark-coloured. According to Hermann, the bile in cholera contains an excess of resin.

In cases of fatty degeneration of the liver, there is, according to Thénard, a diminution of the biliary resin, and the bile appears as a mere albuminous fluid, and by the time that the liver contains five sixths of its weight of fat, the bile loses all its original characters.

Lehmann[4] states that the bile of a dropsical boy developed a large amount of hydrosulphate of ammonia, a circumstance which, in other cases, did not occur even when the bile had been kept for some days.

[1] [Scherer has recently investigated the composition and properties of biliary colouring matter. A notice of his researches may be found in my Report on the Progress of Chemistry in "The Half-yearly Abstract of the Medical Sciences," vol. i, 1845.]

[2] Journ. de Chim. Méd., vol. ii, p. 461.

[3] Cholera Archiv, vol. i, p. 399.

[4] Summarium, vol. xii. 1839.

Bile of Animals.

The bile of animals has been examined by Berzelius, Gmelin, Thénard, myself and other chemists.

[According to the latest observations of Berzelius, filtered ox-gall, when evaporated to dryness at a temperature of 266°, gives off 928·38 parts of water, and leaves 71·62 of solid residue, consisting of—

Mucus	2·310
Extractive matter insoluble in alcohol, with alkaline sulphates and phosphates	4·334
Chloride of sodium, lactate of soda, and extractive matter soluble in alcohol	15·000
Bilin and cholepyrrhin	50·000
Cholesterin	·001

According to Enderlin,[1] the following salts occur in the bile of the ox:

Choleate (or bilate) of soda,
Tribasic phosphate of soda,
Alkaline sulphates,
Chlorides of sodium and potassium,
Phosphate of lime,
Phosphate of magnesia,
Phosphate of peroxide of iron, and occasionally
Sulphate of lime.

The bile of the ox and of the swine has likewise been analysed by Thénard, and the bile of the dog by Gmelin, but the descriptions are of so vague a character as to be of little or no use. The same objection applies to their examination of the bile of various birds.]

In the bile of the *Python bivittatus* Berzelius found bilin (as in the mammalia), a small quantity of bilifellinic acid, bile-pigment the same as in other classes of animals, a little crystalline biliary matter precipitable by carbonate of potash, similar to that which occurs in the bile of fishes, ptyalin or a substance resembling it, a peculiar animal matter soluble only in boiling water, fatty acids, and the ordinary salts. The bile of the *Coluber*

[1] Annalen der Chemie und Pharmacie, 1844.

natrix is described by Gmelin as of a grass-green colour, transparent, perfectly fluid, and passing through the ordinary change of colour (blue, red, and yellow) on the addition of nitric acid.

The bile of the *Rana esculenta* and *R. temporaria* is very fluid, of a pale green colour, and yields the ordinary series of tests with nitric acid. The bile of the water-frog leaves a somewhat crystalline residue on evaporation; the bile of the grass-frog has a sweetish taste, and is less bitter than fish-bile.

The bile of the *Cyprinus leuciscus* is described by Gmelin as green, transparent, and fluid, communicating a sweet and afterwards a very bitter taste to the gustatory organs, neutral in its reaction, affected, as to its colour, by nitric acid like other bile, and coagulating immediately on the addition of potash into a greenish white granular mass, becoming covered, on evaporation, with an almost colourless crystalline film, and yielding 14·3% of a dark green, transparent, crystalline residue.

The bile of the *Cyprinus barbus* is similar to that of *C. leuciscus* in its physical characters, and yields 19·3% of a dark green crystalline residue.

The solid residue of the bile of the *Salmo fario* and *Esox lucius* is stated to be non-crystalline.

On the Action of the Bile in the process of Digestion.

We are as ignorant of the action of the bile on the chemical changes that the food undergoes in the intestinal canal and in the process of chylification, as of the exact influence of the saliva or of the pancreatic juice. Experiments, with the view of deciding this point, have been instituted by Brodie and by Tiedemann and Gmelin, and the conclusions to which they lead are, that the bile does not exert any material influence upon digestion and chylification. Assuming that these experiments were correctly performed, the bile must be regarded as a mere excretion, whose removal from the organism is as necessary for the preservation of the normal constitution of the blood as the removal of carbonic acid, urea, &c.

Tiedemann and Gmelin state as the results of their observations on animals, in which the flow of bile into the intestine was prevented: 1st, that digestion (as had been stated by Brodie) proceeds just as perfectly as when the supply of bile is not

hindered; 2d, that the contents of the small intestine, cæcum, and large intestine, after the application of a ligature to the ductus communis choledochus, do not differ in any essential degree from their ordinary state; and 3d, that the bile plays no essential part in the formation of chyle.

Notwithstanding these general conclusions, they found that the chyle of dogs, in whom the ductus communis choled. was tied, was perfectly clear, whilst in the natural state it is white and turbid in consequence of the fat held in suspension, a difference not to be passed over as altogether unimportant. Another undeniable effect of the bile in chylification consists in the neutralization of the free acid of the chyme by the alkali that is associated in so unstable a manner with the biliary secretion, in consequence of which the bilin gradually begins to undergo certain changes, but whether of the same nature as in the laboratory of the chemist it is impossible to decide.

[That the bile is not merely an excrementitious fluid, intended to remove effete matter from the blood, but that it is a secretion essential to the animal economy, was rendered almost certain by the experiments of Berzelius, Theyer, and Schlosser, which showed that the human fæces contained much too small a quantity of a substance resembling bile to justify the idea that it is evacuated in this manner. A further proof that the bile is absorbed and not excreted is afforded by an examination, made by Enderlin, of the ash yielded by the contents of the different portions of the intestinal canal of a hare. He found that the ash from the contents of the duodenum *alone* effervesced on the addition of an acid, thus showing that the choleate of soda (which yields the carbonate on incineration,) is absorbed before reaching the jejunum. Schwann has recently established this opinion beyond a doubt, by a series of well-devised experiments on dogs. He tied the ductus communis choledochus, and at the same time formed a fistulous opening in the gall-bladder, by which the bile escaped externally. His most important conclusions are, 1st, That when the bile does not get into the bowel, its absence is generally perceptible in dogs, about the third day, by a marked diminution in weight; and, 2dly, That unless the channel for the conveyance of bile to the duodenum is re-established, symptoms of deficient nutrition,

wasting, debility, &c., ensue, and death is the ultimate consequence.]

If the bilin becomes decomposed in the intestinal canal into various constituents, through the influence of the acid chyme, then a wide field of investigation is open to us respecting the function of the biliary secretion in relation to chylification. No explanation has yet been afforded of the discrepancy in the amount of albumen contained in the chyme absorbed by the intestinal villi, and in the chyle discharged by the absorbents, (even without passing through the mesenteric glands.) May it not happen that a constituent of the bile acts on some hitherto ill-defined protein-compound of the chyme, and converts it into the form known as uncoagulated albumen?

ON THE GASTRIC JUICE, DIGESTION, AND THE CHYME.

Gastric Juice.

The gastric juice has been examined by numerous chemists, in consequence of the importance attributed to it in the process of digestion. There have been found in it free acids, a considerable amount of salts, and certain indefinite animal substances, which were known at the period to which we refer as osmazome or salivary matter. Experiments on artificial digestion have thrown much light on the nature of the gastric juice. Eberle[1] proved that an artificially-formed gastric juice does not thoroughly dissolve food, unless a small quantity of gastric mucus, or a portion of the mucous membrane of the stomach be added to it. On the strength of this discovery, Müller and Schwann[2] instituted a series of experiments, from which Schwann was led to conclude that the gastric juice contains a peculiar substance, which, cooperating with an acid, possesses the property of rapidly dissolving substances insoluble in mere water, or in a mixture of extractive matters, salts, and a little acid, as for instance, fibrin, coagulated albumen or casein. To this

[1] Physiologie der Verdauung. Würzburg, 1834.

[2] Ueber die künstliche Verdauung des geronnenen Eiweisses, Müller's Archiv, 1836.

somewhat problematic substance he gave the name of *pepsin:* Wassmann[1] and Pappenheim[2] have endeavoured to isolate it. (See Vol. I, p. 224.)

Prout[3] has shown that the free acid of the gastric juice is muriatic acid. Gmelin and Tiedemann[4] have found it associated with acetic acid, and in the gastric juice of horses, with butyric acid: there is no doubt that lactic acid is likewise contained in it. From the researches of the latter chemists, which are the most perfect that we possess on the subject, it appears that in addition to the free acids, the gastric juice contains mucus, and occasionally (in horses) a very small quantity of albumen, extractive and salivary matter, and that the ash consists of alkaline muriates and sulphates, a little phosphate and sulphate of lime, chloride of calcium, magnesia, and peroxide of iron.

The gastric juice collected from the empty stomach, although mixed with mucus, was tolerably clear; it was neutral, of a yellow colour, a saline taste, and on evaporation left only 2% of solid constituents. Gastric juice obtained by irritating the stomach with pebbles was acid, viscid, and of a pale brown colour. Hünefeld does not believe that there is any free hydrochloric acid in gastric juice.

Berzelius analysed gastric juice collected by Beaumont from a young man with a fistulous opening into the stomach. It had been kept for five months before Berzelius received it, and was therefore totally unfit for the purpose of analysis. In that condition it was clear, yellow, devoid of odour, reddened litmus paper in a decided manner, and left a solid residue of 1·269%, consisting principally of crystals of chloride of sodium, in the interstices of which was a brown extractive matter, which, on exposure to the air, resolved itself into a dark brown thick syrup. Its quantity was too small to admit of its being accurately examined, but it was proved to contain lime and a protosalt of iron. Beaumont describes human gastric juice as a clear, inodorous, saline, and very acid fluid, which effervesces on the addition of alkalies. Dunglison detected in it free hydrochloric acid, an animal substance soluble in cold but not in

[1] De Digestione nonnulla. Diss. inaug. Berol. 1839.

[2] Zur Kenntniss der Verdauung. Breslau, 1839.

[3] Philos. Transactions, 1824, p. 45.

[4] Die Verdauung nach Versuchen, p. 150.

hot water, and acetic, phosphoric, and hydrochloric acids, in combination with potash, soda, lime, and magnesia.

The gastric juice of a horse, collected by irritating its empty stomach with pebbles, was found by Gmelin to contain:

Water . . .	984·00
Solid residue . .	16·00
Organic constituents .	10·52
Salts soluble in water .	5·02
Salts insoluble in water .	0·46

[Braconnot has examined the gastric juice collected by means of sponges from the stomachs of dogs, but his results are not very definitely given.]

Hence it appears that the principal constituents of the acid gastric juice are pepsin; a substance not yet carefully examined, but bearing a close resemblance to extract of flesh; an unexamined substance resembling salivary matter; free acids, especially muriatic acid; mucus; sometimes a little albumen; salts, especially alkaline chlorides, muriate of ammonia, (according to Hünefeld,) and a small quantity of earthy salts.

[M. Blondlot has recently published a treatise on Digestion,[1] detailing very numerous experiments made upon dogs, in which fistulous openings into the stomach were maintained for upwards of two years. The gastric juice was obtained in very large quantities. Submitted to distillation, the fluid passing over did not exhibit the slightest acid reaction, whilst the residue in the retort was always strongly acid. Hence he concludes that the acid of the gastric fluid is neither hydrochloric nor acetic acid, since both these are volatile. The gastric fluid of other animals gave the same result on being distilled. When chalk or any other carbonate of lime was added, no effervescence ensued, proving the acid not to be the lactic. M. Blondlot concludes that the acid reaction of healthy gastric juice is owing to the presence of superphosphate or biphosphate of lime. He adds—1st. That there is no other acid fluid which can remain acid, and fail to decompose carbonate of lime. 2d. That sulphuric acid, added to gastric juice,

[1] Traité analytique de la Digestion. Paris, 1843.

precipitates an abundance of sulphate of lime, and oxalic acid precipitates oxalate of lime. 3d. Potass, soda, ammonia, and lime water, produce abundant precipitates of neutral phosphate of lime. 4th. That the calcined ash of gastric juice is not deliquescent, dissolves without effervescence in hydrochloric acid, forming chloride of calcium; it therefore contains neutral phosphate of lime, the excess of acid being driven off in the calcination.

M. Blondlot believes that the digestive property of gastric juice depends, not on its obvious chemical constitution, but upon a peculiar organic principle. If exposed to a temperature of 104° to 122° F., or higher, it loses entirely and irrevocably its digestive powers, although to all appearance, and even as to its composition, as made known by analysis, it remains unchanged. With the exclusion of the air, gastric juice may be kept for two years without loss of its activity; but with the free access of air, it putrefies in five or six days, although the chyme which it forms from nitrogenous organic substances may be preserved for two or three months without change. The precipitation of all the lime it contains does not affect its activity, nor are its chlorides indispensable, but whatever acts upon its organic constituents, (heat, strong alcohol, or strong acids,) or which removes them, (such as animal charcoal, chlorine, tannic acid, or acetate of lead,) destroys all its digestive properties.

M. Blondlot also shows—*a*. That coagulated albumen resists the action of the gastric juice only from its compact form. When coagulated in very small particles, as the white of an egg beaten into a froth and poured into boiling water, it is digested as quickly as soft fibrin. *b*. That the action of the stomach in coagulating milk is not due to its digestive principle solely, but to its acid, which acts like lactic acid. *c*. That the effect of the gastric fluid upon bones, whether entire or not, is to disintegrate them slowly, beginning at the surface, and to reduce the earthy matter into a fine chalky powder, but without dissolving or decomposing it. The earthy matter not being dissolved, proves that no hydrochloric acid has acted upon it; it is all discharged with the fæces.

Since the work of M. Blondlot was published, two other French chemists, MM. C. Bernard and C. Barreswil,[1] have made

[1] Journal de Pharmacie, Jan. 1845.

an experimental investigation into the properties of the gastric juice. They start with the assumption that this fluid owes its digestive properties to the union of two principles: 1st, an acid; 2d, a peculiar organic matter destructible by heat. What is the nature of the acid? "The principal fact which has been adduced to prove that the acid reaction is owing to the presence of biphosphate of lime is, that it may be treated with carbonate of lime without effervescence. Our experiments show that this arises from the dilution of the acid, which allows the carbonic acid to be dissolved as it is formed. When, therefore, the gastric juice is concentrated, it causes a considerable effervescence with chalk. Moreover, gastric juice dissolves neutral phosphate of lime, whilst this salt is entirely insoluble in a solution of the biphosphate. On distilling gastric juice, the first distillate exhibits no acid reaction. If a mere trace of acetic acid or acetate of soda is added previous to distillation, it gives an acid reaction; the normal acid is not therefore acetic. This also appeared, at first sight, to prove it could not be hydrochloric acid; but on distilling water rendered slightly acid by hydrochloric acid, nothing passes over at first but pure water, the acid not distilling until the end of the operation. On distilling gastric juice a neutral limpid liquor passes over, which is not precipitated with nitrate of silver; when about four fifths has distilled over, the distillate is perceptibly acid, nevertheless, it does not render a solution of nitrate of silver turbid; but at the end, and when only a few drops of the gastric juice remain in the retort, an acid liquid passes over which precipitates salts of silver; this is, doubtless, hydrochloric acid. Does this acid exist free in gastric juice, or has a chloride been decomposed in this operation? When the least trace of oxalic acid is added to gastric juice which we know contains lime, a turbidity is produced from the formation of an insoluble oxalate of lime; but if to water acidified with 2000ths of its amount of hydrochloric acid, and containing chloride of lime, the same reagent be added, no turbidity ensues. This clearly proves that hydrochloric acid exists as a chloride in the gastric juice, and not in a free state.

When concentrated by evaporation, gastric juice is strongly acid, effervescing with chalk, and not loosing its acid reaction in the presence of an excess of the chalk. This proves the pre-

sence of phosphoric acid. On saturating the acid with lime and oxide of zinc, and filtering the solution, the neutral filtrate contains both zinc and lime, therefore phosphoric acid is not the only free acid in the juice. What is the acid combined with the zinc and lime in the filtered solution? It is one which, as we have seen, passes over at the end of the distillation, and does not precipitate salts of silver. These characters belong to lactic acid. On distilling water slightly acidulated with lactic acid, a small quantity of chloride of sodium being added, we obtain a fluid analogous to gastric juice; first, pure water passes over, then an acid which does not precipitate salts of silver, and the last drops carry over hydrochloric acid. So that it is evident that the presence of hydrochloric acid in the last product of distillation of the gastric juice is owing to the decomposition of the chlorides by lactic acid."

Hydrochloric acid cannot exist in a free state in the presence of a lactate, a phosphate, or an acetate. "We have observed," say the authors, "in the acid of the gastric juice all the characters of lactic acid, as pointed out by M. Pelouze; both give soluble salts of lime, barytes, zinc, and copper, a double salt of copper and lime, deeper in colour than the simple salt, and a salt of lime soluble in alcohol, precipitated by ether." From the above facts, MM. Bernard and Barreswil conclude that the acid reaction of the gastric juice is not owing to biphosphate of lime, but arises from a free acid, which is not hydrochloric or acetic acid. They have always found lactic acid, with a minute proportion of phosphoric acid, the latter being a product of the reaction of the lactic acid on the phosphates present. In their opinion, lactic acid is a constant production of the stomach. They do not mean to say that the digestive powers of the gastric juice are owing to lactic acid; on the contrary, they think if an acid reaction be indispensable, other acids may supply its place, because among the various salts constantly introduced into the stomach with the food, some will have their acid replaced by the free lactic of the stomach, and the new acid liberated may supply the place of the normal acid.

In a more recent memoir they enter more fully into the nature of the active organic matter, on the presence of which they believe the digestive power of the gastric juice to depend. It is precipitated and destroyed at a temperature of 190°. One

of the most remarkable of its properties is that its digestive powers vary according to the medium in which it is contained. In the gastric juice, which is acid, it dissolves nitrogenous matters, such as fibrin, gluten, and albumen; but exerts no action on baked starch; but if the gastric juice is rendered alkaline by the addition of a little carbonate of soda, it rapidly dissolves the starch, and no longer possesses the power of acting on the nitrogenous matters. As these physiological properties are exactly those of saliva and the pancreatic fluid, it became an interesting point to ascertain if a change in the reaction of these fluids would cause a corresponding variation in their solvent power. This was found to be the case; on acidulating these naturally alkaline fluids, their ordinary mode of action was inverted, and they were enabled to dissolve nitrogenous matters, while their capability of dissolving starch was lost. From numerous and varied experiments they believe that one and the same organic principle (the agent of digestion) exists in the gastric juice, the pancreatic fluid, and the saliva, and that its physiological action varies according to the acid or alkaline nature of the fluid in which it occurs.

M. Melsens[1] has also examined the gastric juice, and denies the accuracy of Blondlot's conclusions.]

The fluid secretion in the crops of birds is stated by Gmelin and Tiedemann to have an acid reaction; and the fluid in the glandular stomach, even when empty, contains free acids, especially muriatic and acetic acids.

Brugnatelli observed that Iceland spar inclosed in tubes is decidedly attacked after remaining for some time in the stomachs of hens and turkeys; and Treviranus noticed that a porcelain basin, in which the chyme of hens had been digested, was corroded, from which he concluded that fluoric acid was present. Tiedemann and Gmelin did not succeed in detecting fluoric acid in the gastric juice of ducks, although they carefully sought for it.

Morbid Gastric Juice.

It is well known that the gastric juice sometimes assumes anomalous characters, but important as such modifications are

[1] Journal de Pharmacie, Jan. 1845.

to practical medicine, little is known with certainty in relation to their true causes, and still less respecting the peculiar influences that morbid gastric juice exercises on chymification and chylification. The question naturally suggests itself, whether morbid changes in the gastric juice may not be the origin of many of the diseases of early childhood. Such changes may originate purely from internal causes (nervous influences,) or from a complication of the above with external influences, such as diet, &c.

The only modifications respecting which we can speak with any degree of certainty are the following: 1st, There may be a considerable excess of free acid; 2dly, There may be a diminution of free acid; and 3dly, The gastric juice may become positively alkaline. In all probability, with these there are associated other changes in the composition of the fluid, producing an injurious effect on the process of digestion; but on this subject we are unable to speak with certainty.

The increased acidity of the gastric juice usually arises from an excess of those acids which exist in it in a normal state, namely, muriatic, acetic, and lactic acid. When there is a tendency to the formation of an excess of acid in the gastric juice, it appears to be developed from the food. Muriatic acid is principally developed from animal food; acetic and lactic acids from vegetable and especially saccharine food, such as acid bread, beer, and wine; and the fatty acids from an excessive use of fatty matters. An excessive acidity of the gastric juice is frequently observed in cases of gastritis serosa, and of scrofula and rickets associated with disease of the spleen. In gout, podagra, and nettlerash, the gastric juice contains, according to Stark[1], phosphoric and uric acids; the presence of the latter acid must however be regarded as very problematical.

The cases in which the gastric juice exhibits a positively alkaline reaction are comparatively rare. This deviation from the normal condition arises chiefly from the use of salted or putrid food and drink containing basic salts, from prolonged fasting, and especially from care and anxiety (Stark.)

The experiments of Purkinje and Pappenheim show that when the gastric juice is mixed with bile, its digestive powers are diminished.

[1] Allgem. Pathologie, p. 848.

Our knowledge of the uses of the gastric juice in the process of digestion, is much clearer than that of the other fluids already described, as the saliva, pancreatic juice, and bile. We know that alimentary matters insoluble in mere water are readily dissolved by the pepsin of the gastric juice combined with a little free dilute acid, and that some of these substances become chemically changed during the process of solution.

The intestinal fluid.

The small intestines, when empty and not irritated, secrete an almost neutral, very viscid fluid, but during digestion, or when irritated, the secretion becomes decidedly acid. We cannot examine this fluid in a state of purity, but it is most probable that in its constitution it is similar to the gastric juice, and that it possesses the property of acting on those substances which have escaped the solvent power of that fluid. According to Tiedemann and Gmelin it contains a large quantity of albumen; this is, however, most likely due to the pancreatic fluid which becomes mixed with it. It must also be more or less mixed with the biliary secretion.

On the process of Digestion, and the Chyme.

By the process of digestion we understand the solution and the modifications that the food undergoes in the stomach and adjoining portion of the intestinal canal, together with the absorption and metamorphosis of the nutrient fluid (chyme) contained in the reduced pulpy mass of the food, till it becomes perfect chyle.

The subject of digestion has attracted much attention for the last seventy years, but unfortunately the results that have been obtained are by no means proportionate to the time and labour involved in the experiments instituted in relation to this department of physiology.

The discovery and isolation of pepsin forms a new epoch in the chemical history of digestion. It is now in our power to institute experiments on artificial digestion with every prospect of success; we can examine the new products that are developed, and we shall be thus led to the true understanding of the for-

mation of chyle, which as we know is always tolerably constant in its composition, although evolved from the most diverse species of nutriment.

Previously to commencing such researches, it would be requisite to study and examine the pepsin obtained from different classes of animals; for it is very possible, as Berzelius suggests, that it may be a mixture of various substances, differing in different classes of animals. On this account, various simple natural substances, after the addition of a due quantity of acid (which must be determined experimentally,) should be artificially digested with the different sorts of pepsin, and the products, both soluble and insoluble, carefully analysed. Such terms as osmazome, salivary matter, &c. must be rejected. The researches of Berzelius and myself have opened the way for an exact and separate determination of the extractive matters and ptyalin. We should then be enabled to see what real connexion there is between the substances resembling extract of flesh which are produced in artificial digestion, and those that are actually obtained from flesh itself.

Our knowledge of the changes that the different elements of food undergo in the process of digestion is at present very limited; it is confined to the following leading points.

1. Albumen is dissolved and chemically changed. This observation was made by Eberle, and has been confirmed by Müller, Schwann[1], and others. The digested albumen no longer coagulates at the boiling point; it is stated to have been changed into osmazome and salivary matter, (a vague statement requiring further proof,) and according to Schwann, into a third albuminous principle, which is thrown down by carbonate of soda, and in that condition is insoluble in water and spirit, soluble in muriatic and acetic acids, and not precipitable by acetate of lead or alcohol, but copiously by nitric acid and bichloride of mercury, and partially by ferrocyanide of potassium and tannic acid.

2. Coagulated casein is partially converted by artificial digestion into albumen; soluble casein becomes coagulated when submitted to the action of a solution of sugar of milk and pepsin, but not when acted on by the pepsin alone.

3. Fibrin is rapidly dissolved, and, from the experiments of

[1] Müller's Archiv, 1836, p. 68.

Tiedemann and Gmelin, appears to be partially converted into albumen.

4. Glutin becomes so changed by artificial digestion, that it loses its property of gelatinizing, and can no longer be precipitated by chlorine.

5. Sugar of milk, when submitted for a sufficient time to the action of pepsin, becomes completely converted into lactic acid. This fact has been established by Fremy and myself.

6. Starch is partially converted into sugar. (Tiedemann and Gmelin.)

7. The fluid found in the stomach of a horse, fed with oats, contained butyric acid, a resin, a substance resembling extract of flesh, salivary matter, and albumen.

From recent experiments on digestion, we know that alimentary substances are dissolved as rapidly in an artificial digestive fluid, consisting of pepsin and properly diluted muriatic acid, as they are in the gastric juice itself. Hence we are justified in the conclusion that pepsin, the free acid, and a suitable temperature, are the principal agents in gastric digestion, and that the motions of the stomach are chiefly with the view of promoting the due admixture of the food with the secreted fluid, and of propelling it towards the pylorus, through which it must pass in order to enter the duodenum. It is impossible to state with certainty whether the pepsin and free acids dissolve and modify the food through a catalytic influence, or whether they enter into any chemical combination with it, the products of these combinations being the dissolved and changed matter. If, however, the conversion of sugar of milk into lactic acid is explained by the catalytic action of the pepsin, we may fairly conclude that the pepsin exerts a similar influence on other substances, if no facts to the contrary present themselves. Hünefeld is inclined to attribute considerable influence in digestion to the ammoniacal salts of the gastric juice, in consequence of having observed that under certain conditions fibrin is readily soluble in the muriate or lactate of ammonia, especially when free lactic acid is also present.

The various articles of food are dissolved in the process of digestion with different degrees of facility. Those which approximate most closely to the constituents of the chyle, obviously require the least modification, as, for instance, the fluid

albumen and yelk of egg, fibrin, boiled albumen, muscular flesh, casein, and the protein-compounds generally. Certain substances are not at all digestible, as, for instance, woody fibre, husks of fruit, horn, hair, &c. We always observe a relation between the degree of the changes requisite for the assimilation of different sorts of nutriment, and the complexity of the digestive apparatus. Hence, in the carnivora, the intestinal canal is much shorter and simpler than in the herbivora.

In the ruminantia, the first two stomachs do not secrete an acid, true gastric juice, such as occurs in the stomachs of men and carnivora, but a thin yellow saline fluid containing enough alkaline carbonates to produce a marked effervescence on the addition of an acid. Their nutriment (grass, hay, &c.,) after being chewed and mixed with saliva, is first received into these stomachs, where it is soaked in the alkaline fluid, which dissolves and takes up vegetable albumen and glutin. The fluid gradually passes onwards into the third stomach, while the insoluble portion returns to the mouth for a second mastication. The fluid obtained by pressure from the contents of the first stomach (the paunch) contains, according to Tiedemann and Gmelin, carbonic acid and sulphuretted hydrogen, albumen in combination with soda, carbonate of ammonia, and certain animal matters, one of which is volatile and assumes a red tint on the addition of muriatic acid. In addition to carbonic acid and sulphuretted hydrogen gases, the first two stomachs occasionally develop (especially after the use of fresh clover) an extraordinary quantity of carburetted hydrogen. The third stomach secretes an acid fluid, and in the fourth stomach the acidity is much more marked, the substances dissolved by the alkali being first precipitated and then redissolved in the excess of acid. Finally chyme is produced, said to be analogous to that which is formed in the stomachs of men and carnivora.

In birds the food is first moistened in the crop with a faintly acid fluid; from thence it passes into the proventriculus, where it meets with a peculiar and very acid fluid, and it finally reaches the muscular stomach, which effects its thorough trituration.

On leaving the stomach the food enters the small intestine, where it becomes mixed with the pancreatic juice and the bile. Here it commences to be absorbed by the intestinal villi; more-

over, it is here mixed with the intestinal secretion, and it is probable that the digestion, not entirely accomplished in the stomach, is here perfected.

There are many points connected with the process of digestion which have not been hitherto explained. We may especially instance the conversion of chyme into chyle. It is very difficult to understand the source of the large quantity of albumen found in the chyle, even before it has passed the mesenteric glands, and just after its absorption by the intestinal villi.

An experiment made by Tiedemann and Gmelin on the chyme and the chyle of a horse fed with oats, will place the difference clearly before the reader.

a denotes the fluid expressed from the thick, pulpy, acid contents of the stomach. It was of a brownish yellow colour, turbid, became darker on exposure to the air, and much more turbid on boiling, and on the addition of bichloride of mercury. *b* is the brownish yellow fluid from the duodenum. *c* is the brownish yellow fluid obtained from the central portion of the small intestine, mixed with mucous flocculi and with a tough albuminous substance, apparently resembling salivary matter. *d* is the brownish yellow fluid from the lower part of the small intestine. *e* is chyle from the absorbents before its entrance into the mesenteric glands. *f* is chyle from the absorbents after its passage through them: and *g* is chyle from the thoracic duct.

We shall omit the amount of water in these various fluids, and merely compare the composition of their solid residue.

1000 parts of solid residue contained:

	a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*
1. Resinous matter, with an acid soluble in ether .	1·56	0·79	0·25	0·15			
2. Resinous matter soluble in anhydrous alcohol, alcohol-extract, and salts soluble in spirit . .	61·56	44·61	67·25	77·60	67·50	42·24	30·44
3. Spirit-extract, probably gummy matters and salts	25·26	10·80	5·08	7·10			
4. Insoluble brown matter .		0·66	9·14				
5. Brown nitrogenous matter, soluble only in water		16·32	12·44	7·40	2·50	2·17	3·11
6. Albumen, oxydised extractive matter, and phosphate of lime . .	11·00	7·11	5·03	3·10	27·56	49·82	63·98

The numbers in 2, under *b, c,* and *d,* refer only to the extractive matters and salts soluble in alcohol, while those under *e, f,* and *g* refer not merely to them but also to the fat, the relative proportions of which may be seen in the analyses 4, 5, and 6, of the chyle, in p. 357, vol. I. The numbers in 6, under *e, f,* and *g,* indicate the amount of pure albumen in the chyle, whilst under *b, c,* and *d* extractive matter and phosphate of lime are included. It is to the two lines 2 and 6 of the above table that I wish especially to direct attention. The chyme *b, c,* and *d* differs from the chyle, by a deficiency of fat in the former, and by an excess of albumen in the latter. If the fat is really contained in the chyme, which we cannot doubt that it is, in what state of combination can it occur so as to escape detection? Does the chyme contain fatty acids, combined with the alkalies (soaps), and the chyle, ordinary fat? The chyme contains an extraordinarily large amount of substances soluble in alcohol, whose place in the chyle seems to be supplied by albumen; may we not endeavour to clear up this difficulty by supposing that some still unknown protein-compound, soluble in alcohol, has been converted into albumen? If the chyme contains so small a quantity of pre-existing protein-compounds, as the above analyses *b, c, d* teach us, we must assume that their extraordinary increase in the chyle of the absorbents and of the thoracic duct, must be at least in part due to the influence of the lymphatic glands and vessels, and therefore either directly or indirectly to the blood. But, in opposition to this view, we may remark that it is impossible to conceive that the blood can impart that identical quality to the chyle which renders that fluid the means of supplying nutriment to the blood, and of imparting to it the carboniferous and nitrogenous materials requisite to supply the place of those that have been removed from the body in consequence of waste of tissue. If, however, we bear in mind that the mesenteric veins absorb a fluid from the chyme different from that which is taken up by the lymphatics, we may then perhaps account for the discrepancy between the chemical composition of the chyme and the chyle, by the assumption of a 'vis electiva' residing in the absorbent vessels of these two systems; for the lymphatics absorb and carry off a fluid abounding in protein and nitrogenous compounds, while the venous system takes up an excess of the

compounds of carbon and hydrogen; and since the absorbents of the lymphatic system in the small intestines must have taken up a very albuminous chyle, the chyme examined by Gmelin may on that account have been poor in coagulable albumen, and in the same manner the gradual decrease of the albumen in the chyle, as the large intestine was approached, would be accounted for.

Diseased digestion.

It is by no means rare to meet with an excessive formation of acid both in the stomach and the intestines, especially in children. Acid eructations, a sour smell from the mouth, and frequent green stools, afford indications of a morbid digestion which, doubtless, originates in too acid a condition of the gastric and intestinal fluids, and on the consequent rapid production of lactic and acetic acids from vegetables and milk. I have observed that the fæces of a child at the breast, suffering from improper digestion, consisted of a large quantity of coagulated casein, and a very acid, greenish, whey-like fluid, with numerous oil-vesicles on its surface. The fat was isolated and contained a large amount of the fatty acids.

A copious secretion of gas is a frequent consequence of diseased digestion. This gas is not a mere mixture of carbonic acid and nitrogen with a little hydrogen (the ordinary gases) but also contains a considerable amount of sulphuretted hydrogen, and, in all probability, phosphoretted hydrogen and carburetted hydrogen.

There can be no doubt that there are anomalies in the process of chylification, in consequence of which an unsuitable chyle is prepared and conveyed to the blood, modified both in its quality and its quantity; but with respect to the particulars of these anomalies we are still perfectly in the dark.

CHAPTER IV.

MILK.

The milk is a white, fatty, and rather thick fluid, which is secreted by the female breasts during pregnancy and after delivery. A metastatic or vicarious secretion of milk from the skin, the navel, the groin, the stomach, the intestines, the mucous surface of the genital organs, or the axilla, is by no means rare: it has also been observed in the breasts of men.

General physico-chemical characters of the milk.

Perfectly fresh milk has always a decidedly alkaline reaction, and it retains this property for a longer or shorter time: the milk of women retains its alkaline reaction longer than that of cows; and the milk of healthy women longer than that of invalids.

On examining the milk under the microscope we perceive a great number of fat-vesicles of very different sizes swimming in a clear fluid, and occasionally epithelium-cells. From repeated comparisons I have found that the fat-vesicles in the milk of woman are generally rather larger than those in the milk of the cow. In addition to these fat-vesicles, we observe, under certain circumstances, other microscopic objects, of which I shall treat subsequently. The fat-vesicles have, as Raspail declared, a solid envelope, a point which has been confirmed beyond dispute by Henle and myself. Raspail considers that it is composed of coagulated albumen; it is, however, more than probable that it consists of coagulated casein. Henle[1] has shown that this capsule may be dissolved by acetic acid, and that butter then issues from it; it is probable, however, that this fluid fat becomes inclosed in a new envelope, for Ascherson[2] has observed

[1] Froriep's Notizen, 1839, No. 449.

[2] Ueber die Hautdrüsen der Frösche und über die Bedeutung der Fettstoffe, Müller's Archiv. 1840.

that a membrane immediately forms around every drop of fat that is brought in contact with a solution of albumen; and I have found that fat shaken with a caseous substance (crystallin) in a state of solution, causes a partial coagulation by the formation of such membranes or capsules. I have shown that when woman's milk is evaporated, and the residue reduced to a fine powder, and extracted with ether (which takes up the butter), there are left the capsules of the fat-vesicles, which, when mixed with water, and placed on the object-stage, may be observed with the microscope.

Milk is materially affected by a large number of substances, especially by those that precipitate its casein. The addition of any of these substances causes it to coagulate, that is to say, the casein becomes insoluble and incloses the butter, and thus produces the separation of a whey-like fluid from the caseous mass. A precipitation of this nature is brought about by alcohol which, at the same time, takes up a very small quantity of fat: when milk is shaken with ether, no precipitation of casein ensues, but the milk becomes rather clearer and the ether is found to contain fat, but only a small portion of all that is contained in the milk. When milk is left to itself for a considerable time, it coagulates, in consequence of the conversion of a portion of its sugar into lactic acid: this change often takes place very rapidly in cow's milk, and generally more quickly than in woman's milk. If the milk is allowed to remain still longer exposed to an ordinary temperature, the surface becomes covered with peculiar forms of mould, and, under certain conditions which are not accurately known, particular species of infusoria are developed. These infusoria are the cause of a blue or yellow colouring matter, which is especially distributed over the surface, a phenomenon that has long been observed, and which has recently been carefully investigated by Fuchs.

Rennet likewise precipitates the casein apparently by a catalytic action on the sugar of milk, by which it is converted into lactic acid; hence the precipitation is hindered by the addition of an alkali, and, as Herberger has observed, does not occur in milk which abounds in alkaline salts.

The solid constituents of the milk vary from about 9 to 35%; the specific gravity usually lies between 1028 and 1042.

SPECIAL CHEMISTRY OF THE MILK.

Constituents of the Milk, and methods of separating them.

The following substances are contained in a state of solution in healthy milk: casein, fat (including olein, stearin, butyrin, caproin, and caprin), sugar of milk, extractive matters, and salts. The salts are the chlorides of sodium and potassium; lactates of potash, soda, probably of ammonia, of lime, and magnesia; phosphates of potash, soda, lime, and magnesia; and traces of phosphate of peroxide of iron.

The plans that were formerly proposed for the analysis of milk could not give satisfactory results. For instance, the fatty portion which collects on the surface (the cream) was analysed separately from the poorer fluid beneath it; by this means, then, were obtained accurate estimates of the two separate portions, but not of the milk collectively.

The course adopted by the French chemists, was to evaporate the milk, to take up the butter with alcohol, or a mixture of alcohol and ether, and then to wash out the sugar from the residue; if we reflect, however, that the dried casein of cow's milk is always slightly soluble, and that of woman's milk is freely soluble in water, the source of error in this system becomes at once obvious. By the adoption of this incorrect method, Payen fixed the amount of casein at 0·23%, while the mean of seventeen analyses performed by myself yielded 3·4%, or more than fourteen times as much.

The following is the method that I adopt:[1] a known quantity of milk is evaporated to dryness, and the residue weighed; by this means we determine the amount of water. A weighed portion of the dried and finely-powdered residue is thrice extracted with five or six times its volume of boiling sulphuric ether, in order to remove the fat. After the removal of the fat, the residue is placed in a porcelain basin, is again pulverized, and digested with a little warm water. The pulp which is thus formed is treated with an additional quantity of boiling water, in which it is partially soluble if the analysis is being conducted

[1] Die Frauenmilch nach ihrem chemischen und physiologischen Verhalten, p. 27.

with cow's milk; it dissolves entirely, with the exception of an inconsiderable quantity of coagulated casein, if woman's milk is used. The solution is then evaporated at a gentle temperature to the consistence of a thin syrup, and is treated with ten or twelve times its volume of alcohol of 0·85, which precipitates the casein. As the casein may retain a little sugar, it is expedient to digest it once or oftener with a little water, and to treat the dilute pulp with spirit; the casein that remains must be thoroughly dried and weighed. The spirituous solution contains the sugar, and the greater part of the extractive matter, from which the sugar cannot be easily separated. A partial separation may be effected in this way: we may dissolve the impure sugar in a little water; on the addition of strong alcohol, the sugar with a very little extractive matter, is precipitated, while the alcoholic solution contains extractive matters and a little sugar. On evaporating this solution to the consistence of a syrup, and adding strong alcohol to it while still hot, some more sugar separates on cooling.

I usually estimate the salts by incinerating a weighed portion of the dried residue of the milk; and, in some cases, I have separated the soluble from the insoluble salts.

This analysis of milk does not yield, as Berzelius[1] justly observes, any very accurate results, since casein is slightly soluble in alcohol; although strong cold alcohol takes up only a very small portion, dilute hot alcohol dissolves a considerable quantity. The determination of the sugar and of the extractive matters by the course that I have indicated is still more inaccurate. Berzelius proposes to precipitate the casein (and the butter) by rennet; but it must be observed that, by this means, we do not obtain results of greater accuracy, since a portion of the casein always remains in solution in the whey. This amounts to a considerable quantity in woman's milk, but is comparatively slight in the milk of the cow,[2] and has always to be obtained by means of alcohol from the evaporated solution. In order to precipitate the casein thoroughly by rennet, it would be requisite to supersaturate the free alkali of the milk by acetic or lactic acid; we should then obtain the casein in a state of combination with these acids; in fact, casein precipi-

[1] Thierchemie, p. 698. [2] Die Frauenmilch, &c. p. 33.

tated by rennet from non-acidulated milk does in reality exist in this condition.

If we precipitate the casein of cow's milk by sulphuric acid, and decompose the sulphate by carbonate of lime or baryta, we shall obtain soluble compounds of casein with lime or baryta. The casein of woman's milk is very imperfectly precipitated by sulphuric acid.

If albumen is present in milk, which is sometimes the case, it must be determined by a separate experiment. The milk must be boiled, and the coagulum must be collected and extracted with boiling spirit, in order to remove the sugar and fat; it must then be dried, and its weight estimated. The amount of albumen obtained in this manner is deducted from the amount of casein obtained by the method which has been described, and which must clearly include both the casein and albumen.

[Haidlen[1] has recently proposed a new method for analysing milk. It consists in coagulating the milk by gypsum, by which means the error in the determination of the casein that resulted from all former methods, is avoided.

When milk is stirred with about one fourth of its weight of finely-pulverized gypsum, and heated to 212°, it is entirely coagulated; and if the whole is then evaporated to dryness, a brittle mass is obtained, which is easily reducible to powder. From this powder the butter may be extracted by ether; the sugar of milk and soluble salts may be removed by hot alcohol of 0·85; while the caseate and sulphate of lime, and insoluble salts, remain undissolved. The alcoholic solution scarcely exhibits any perceptible opacity on the addition of chloride of barium, showing that no error in the result is occasioned by any of the gypsum being taken up by the alcohol.

About 100 grains of gypsum and four times its weight of milk answer very well. The soluble salts extracted from the milk by the alcohol may easily be determined by incineration; and since their amount is to that of the insoluble salts in the average proportion of 5 to 7, the amount of the latter may at least be found approximately, and the ascertained weight of

[1] Simon's Beitrage, p. 358.

the sugar and casein corrected accordingly. But if it be required to determine the salts with perfect accuracy, it is best to incinerate a weighed quantity of milk, and to analyse the residue.

The analyses of Clemm,[1] which will be presently noticed, were made in the following manner: One portion of milk was used for the determination of the water and of the solid residue, and afterwards (by incineration) of the fixed salts. Another portion was evaporated nearly to dryness, and treated with one or two drops of acetic acid to coagulate the casein and render it insoluble. It was then treated with ether, in order to remove the fat, and with water in order to take up the sugar of milk, extractive matters, and salts. The residue was regarded as casein.]

Healthy Milk.

1. *Milk before delivery.*

The mammary glands secrete a milky fluid during pregnancy which, at first, differs considerably from normal milk, but, as the period of delivery approaches, gradually approximates to it in its characters. In the first stage of its secretion, albumen preponderates, and sugar is almost entirely absent; the albumen gradually gives place to casein, and, at the same time, sugar and fat are more abundantly formed. There are no means of obtaining any very accurate information respecting the fluid secreted in the breasts of women previous to childbirth,[2] but experiments have been made by Lassaigne and myself on this secretion in animals.

I analysed the milk of an ass pregnant for the first time, and within about fourteen days of her full period of gestation. The fluid was transparent, scarcely opalescent, tenacious, and viscid; it had an alkaline reaction. The microscope revealed a few fat-corpuscles, some granular bodies, composed of accumulated minute fat-vesicles and mucus-corpuscles.

It did not become more gelatinous or stringy on the addition of caustic ammonia; when heated, a considerable quantity of

[1] The investigations of Clemm are contained in the article "Milch" by Scherer, in Wagner's Handwörterbuch der Physiologie, vol. 2, 1845.

[2] [Clemm found that the fluid obtained from the breasts of a woman shortly before delivery contained 5·478% of solid constituents.]

albumen coagulated. The presence of casein was shown, and its amount determined, by the addition of acetic acid, by boiling the fluid till it evaporated to the consistence of an extract, and by then extracting it with boiling spirit. The casein differed from the ordinary casein of cow's milk, in being soluble to a very considerable extent in boiling spirit; it partially separated from the clear hot solution on cooling: it seemed rather to resemble the casein of the crystalline lens. After the removal of the fat, by means of ether, it was almost perfectly soluble in water; on the application of heat, the surface of the solution became covered with an irregular film, and the addition of a little dilute acid was followed by a very copious precipitate.

The analysis of this milky fluid yielded, in 1000 parts:

	Analysis 61.
Water	737·00
Solid constituents	263·00
Fat	7·98
Casein	28·93
Albumen	198·34
Extractive matters, traces of sugar and casein, chloride of sodium, and lactate of soda . . .	18·41

The milk of the same ass was examined eight days afterwards; it was less thick and sticky, and rather whiter than before. It more closely resembled true milk in its smell, and it had a mild, faintly sweet taste. It contained, in 1000 parts:

	Analysis 62.
Water	814·0
Solid constituents	186·0
Fat	8·5
Casein	25·0
Albumen	123·9
Extractive matter, with a little sugar, salts . .	28·6

The change in the constitution of the fluid was very striking; the solid constituents collectively, and especially the albumen, were diminished, while the fat, casein, and sugar, had relatively increased. In the first analysis, the casein formed only one ninth of the solid residue; in the second, it amounted to one seventh.

Lassaigne has observed similar proportions in the fluid secreted by the mammary glands of cows previous to calving. Forty-one days before calving, it contained albumen in place

of casein, had an alkaline reaction, a specific gravity of 1063, and, when allowed to stand, deposited a large quantity of cream, from which a very soft sort of butter was obtained. The fluid retained these properties till ten days before calving; it then acquired a milder taste, but still contained albumen in place of casein. If Lassaigne had been acquainted with my method of separating casein from albumen by means of boiling spirit, he would, doubtless, have found casein, as I did, in the asses' milk. It was not till five days after calving, that the fluid resembled ordinary milk; it then had a specific gravity of 1035, and contained casein instead of albumen.

2. *Milk immediately after delivery.*

The lacteal secretion immediately after delivery differs from the ordinary milk produced after the milk-fever, and has received the name of colostrum. In woman I found the colostrum thicker than true milk.[1] It had a dirty light yellow colour, an alkaline reaction, no peculiar odour, but a remarkably sweet taste.

[Clemm states that the alkaline reaction very soon disappears. He has found the colostrum become acid in the course of three hours.]

According to other observers, it resembles a thin solution of soap and water (Joannide[2]), with drops of oil on its surface. On examining the colostrum with the microscope, a very large number of fat-globules are seen, some of which are larger than those that occur in ordinary milk, and these are frequently observed clinging to one another; besides these, there are granulated, yellow, roundish corpuscles, larger than the milk-corpuscles, which appear to be composed of very minute fat-vesicles; they seem to be peculiar to the colostrum, and were first observed by Donné,[3] who states that they occur in woman's milk till the twentieth day, when the milk loses all the characters of colos-

[1] Die Frauenmilch, &c. p. 51.

[2] Physiolog. Mammar. Mulieb. Specim. Halle, 1801.

[3] Du Lait, et en particulier de celui de nourrices, etc. Paris, 1837, p. 19.

trum; I have never succeeded in detecting them after the eighth or tenth day.

[According to the observations of d'Outrepont,[1] the granulated corpuscles usually disappear on the third day.]

The following analysis represents the composition of 1000 parts of the colostrum of a woman. The other analysis represents the average composition of healthy milk, deduced from many observations, and is given in order that the reader may contrast the composition of the colostrum with that of the normal secretion.

	Analysis 63. Colostrum.	Healthy milk of the same individual.
Water	828·0	887·6
Solid constituents	172·0	112·4
Fat	50·0	25·3
Casein	40·0	34·3
Sugar of milk	70·0	48·2
Ash	3·1	2·3

Of the fixed salts, 1·2 were soluble, and 1·8 insoluble in water.

The chemical differences between the colostrum and the milk are at once obvious; the former is much the richer of the two in solid constituents, especially in butter and sugar of milk. The absolute quantity of casein is also greater, but the ratio of the casein to the solid constituents is less than in ordinary milk. The salts are also increased; the aperient property of the colostrum is probably due to the increased quantity of salts and sugar of milk.

3. *Of ordinary milk.*

The ordinary milk of the human female is a white or blueish fluid, and of a sweeter taste than cow's milk. It usually exhibits nothing but the milk-globules under the microscope. It has always an alkaline reaction, which it retains for five or six days before it becomes acid. Its specific gravity varies from 1030 to 1034; the average of a large number of analyses yielded the number 1032. On evaporation, it becomes covered, like every other sort of milk, with a film of coagulated casein; and when the evaporation has been sufficiently prolonged, it yields

[1] [Neue Zeitschrift für Geburtskunde, vol. 10, pp. 1—7.]

a brownish extract-like residue which, when dried, is perfectly soluble in water, (with the exception of a little albumen,) and forms a milky fluid. Everything that precipitates casein, coagulates milk; the mucous membrane of the stomach of an infant a few days old, that has recently died, seems, from my observations, to coagulate woman's milk more perfectly than the mucous membrane of the stomach of the calf.[1] The solid constituents fluctuate between 8·60 and 13·86%. I shall now give some analyses of milk: 1st, the average of fourteen analyses made at different periods with the milk of the same woman; 2d, the analysis of the milk of a woman aged 36 years; 3d, the analysis of the milk of a nurse aged 20 years; 4th, the maxima, and, 5th, the minima, of numerous analyses.

		An. 64.	An. 65.		
	1.	2.	3.	4.	5.
Water	883·6	894·0	898·0	914·0	861·4
Solid constituents . .	116·4	106·0	102·0	138·6	86·0
Butter . . .	25·3	38·0	28·8	54·0	8·0
Casein . . .	34·3	34·0	32·0	45·2	19·6
Sugar of milk and extractive matters	48·2	40·5	36·0	62·4	39·2
Fixed salts . . .	2·3	1·8		2·7	1·6

The *maximum* table gives the highest amount of each individual constituent, and the *minimum* the lowest that occurred in the whole series of analyses.

[Clemm has recently published the following analyses:

	The 4th day after delivery.	The 9th ditto.	The 12th ditto.
Water	879·848	885·818	905·809
Solid constituents . . .	120·152	114·182	94·191
Butter	42·968	35·316	33·454
Casein	35·333	36·912	29·111
Sugar of milk and extractive matters .	41·135	42·979	31·537
Salts	2·095	1·691	1·939

Two analyses of healthy human milk have been made by L'Heretier.[2] He found:

	1.	2.
Water	867·8	870·6
Solid constituents . . .	132·2	129·4
Butter	42·5	52·0
Casein	11·7	9·5
Sugar of milk . . .	74·0	63·4
Salts	4·0	4·5

[1] Die Frauenmilch, &c. p. 29.

[2] Traité de Chimie Pathologique, p. 627.

Haidlen,[1] by the method already noticed, found that 1000 parts of woman's milk contained:

	1.	2.
Butter	13	34
Casein and insoluble salts	27	31
Sugar of milk and soluble salts	32	43

In the second analysis, the milk was extremely rich in solid constituents.]

Meggenhofen[2] has also analysed woman's milk; but, from the method which he pursued, we can place no reliance on the determination of the individual constituents. The dried residue was extracted with alcohol of 0·83, and afterwards with water, as long as any additional matter was taken up. It is evident that fat, some of the sugar, and perhaps even traces of casein must be contained in the alcohol-extract; the water-extract contains the rest of the sugar, some extractive matter, and a great part of the casein. According to Meggenhofen, the solid constituents in woman's milk vary from 10 to 12·56%, and the salts from 1·2 to 2·4%. These numbers correspond very closely with my results.

The analyses gave in 1000 parts:

Water	827·5	883·5	789·3
Solid constituents	172·5	116·5	210·7
Fat with sugar and alcohol-extract	91·3	88·1	171·2
Sugar and casein	11·4	12·9	8·8
Coagulated casein	24·1	14·7	28·8

Payen[3] has likewise analysed woman's milk, but his results, especially regarding the amount of casein, differ so very much from those of other chemists that they can only be explained on the assumption that there was an error in the plan of his analysis. The following numbers represent the mean of three analyses: water, 857·7; solid constituents, 142·3; butter, 51·5; casein, 2·2; residue of evaporated whey, 78·0.

[1] Annalen der Chemie und Pharmacie, vol. 45, No. 3.

[2] Dissert. inaug. sistens indigationem lact. mul. chemic. auct. Meggenhofen. Frankf. a. M. 1826.

[3] Journal de Chim. méd. vol. iv, p. 118.

The salts of woman's milk appear, according to my own observations, and those of Meggenhofen, to range at about from $\frac{1}{3}$ to $\frac{1}{4}$ per cent. of the fluid; of these, usually about $\frac{2}{3}$ are insoluble, and $\frac{1}{3}$ soluble in water: the former consist of phosphate and carbonate of lime, with a little magnesia, and a very small quantity of (phosphate of?) peroxide of iron; the latter, of chlorides of sodium and potassium, with a little chloride of calcium, carbonate of soda, (corresponding with the lactate in the milk,) and a little sulphate of potash, the acid of which does not pre-exist in the milk, but is produced during incineration. Pfaff and Schwartz[1] found a larger proportion of salts in woman's milk, namely, 0·4407%; they were composed of phosphate of lime, 0·25; phosphate of magnesia, 0·05; phosphate of iron, 0·0007; phosphate of soda, 0·04; chloride of potassium, 0·07; and soda originating from lactate of soda, 0·03. Carbonate of lime, sulphate of potash, and chloride of sodium are not noticed, although all other observers concur in finding them in the milk.

Chevallier and O. Henri have instituted some researches on the milk; they precipitated the casein by acetic acid, evaporated the fluid portion, and determined the salts by the incineration of the residue. They estimated the part that was consumed as sugar of milk, and removed the fat from the precipitated casein by means of ether. By this process they obtained much too small a quantity of casein from woman's milk, (since this constituent is only imperfectly precipitated by acetic acid,) and too large a quantity of sugar, which was thus made to include all the destructible constituents, with the exception of the casein and fat. In the other sorts of milk, the precipitation of the casein by acetic acid is also imperfect. The following is the result of their analysis of woman's milk:

Water	879·8
Solid constituents	120·2
Butter	35·5
Dried casein	15·2
Sugar of milk	65·0
Salts	·4·5

[1] Dissert. inaug. sistens nova experimenta circa lact. princip. constit. Kiel, 1833.

On the effect of temperament on the milk.

[It has been long believed that the milk of fair women is inferior in its properties to the milk of brunettes. As far as I am aware, the only analyses bearing on this point are those of L'Heretier. He selected two females of equal age, and made them submit to the same diet and mode of life. The following are the results of his analyses:

	A Blonde, aged 22.		A Brunette, aged 22.	
	1.	2.	1.	2.
Water	892·0	881·5	853·3	853·0
Solid constituents	108·0	118·5	146·7	147·0
Butter	35·5	40·5	54·8	56·3
Casein	10·0	9·5	16·2	17·0
Sugar of milk	58·5	64·0	71·2	70·0
Salts	4·0	4·5	4·5	4·5

He appears to have selected the analyses that presented the most marked contrast; for he observes, that if he had taken the mean of all his analyses, the difference between the amount of the solid constituents in the two cases would have been less marked, the average ratio being 120 : 134.

L'Heretier has likewise investigated the changes produced in the milk by a prolonged sojourn in the breast. The two following analyses illustrate the effect thus produced. The milk in each analysis was afforded by the same woman: in the first case it had remained in the breasts for forty hours; in the second, it was obtained after the infant had been sucking for some little time.

	1.	2.
Water	901·1	858·0
Solid residue	98·9	142·0
Butter	34·0	36·5
Casein	1·9	13·0
Sugar of milk	58·5	78·0
Salts	4·5	4·5]

On the changes in the milk dependent on nutrition.

That the character of the food exerts an influence on the quality and quantity of the milk, is a fact that has been long known, although the nature of the changes could not be cor-

rectly determined. I analysed the milk of a very poor woman fifteen times at regular intervals during the course of half a year, commencing with the second day after delivery. It so happened that she was suddenly deprived of the means of obtaining even the most ordinary necessaries of life. The milk secreted at this period, (the 11th of November,) was sufficiently abundant in quantity, but was very poor in solid constituents, containing only 8·6%. Some days afterwards (the 18th of November) she was placed upon a full and nutritious meat diet. The milk, in consequence, was secreted so copiously as to run spontaneously from the breasts: it left 11·9% of solid constituents. Her circumstances again became very bad, and she was frequently in a state of the utmost destitution: on the 1st of December, while in this condition, the milk again became very thin, and left only 9·8% of solid constituents. I concluded my researches on the milk of this woman, by an examination on the 4th of January, after she had been supplied for two days with a nutritious meat diet: the milk was then very rich in solid constituents, and left a residue of 12·6%.

The following are the results of my examinations on these four occasions; below them is the average of the fourteen analyses to which I have already referred:

	Water.	Solid constituents.	Butter.	Casein.	Sugar and extractive matter.
1. Milk on Nov. 11th .	914·0	86·0	8·0	35·5	39·5
2. Ditto Nov. 18th .	880·6	119·4	34·0	37·5	45·4
3. Ditto Dec. 1st .	920·0	98·0	8·0	39·0	49·0
4. Ditto Jan. 4th .	873·6	126·4	37·0	40·0	46·0
5. Average of 14 analyses	883·6	116·4	25·3	38·3	48·2

It is evident from these analyses, that however much the nutriment of the mother may vary, no great influence is thereby exerted on the relative quantities of casein and sugar. The changes consist in a greater or less degree of saturation, in the rich yellowish white or the blueish colour, in the quantity of the milk, and in its amount of solid constituents; with the exception of the variation in quantity, all the other changes are dependent on an increase or diminution of the butter; the former occurs under the use of a copious and nutritious diet, the latter when the food is poor and scanty. Donné's[1] proposal

[1] Du Lait, etc. p. 54.

for determining the goodness of the milk by a microscopic examination, is founded on incorrect principles; he assumes that the increase of the butter* and of the other constituents is simultaneous; an assumption that the above analyses show to be inconsistent with facts.

Changes in the milk, corresponding with the age of the infant.

It seems probable that certain changes will be observed in the milk when the progress of development of the child indicates the necessity for other food. The question is one of considerable physiological interest, and in order to elucidate it I made analyses of the milk of a woman during a period of nearly six months, commencing with the second day after delivery, and repeating my observations at intervals of eight or ten days.

The results would doubtless be more decisive if the experimentalist were able to exclude all disturbing influences: but in almost all cases the exercise of a strict control over the method of living and the nature of the food of the mother, is just as impossible as the exclusion of exciting moral forces.

The fourteen analyses (the colostrum being excluded) gave the following results:

Analyses		Specific gravity.	Water.	Solid constituents.	Casein.	Sugar.	Butter.	Fixed salts.
66	31st Aug.	1031·6	873·2	126·8	21·2	62·4	34·6	0·84
67	7th Sept.	1030·0	883·8	116·2	19·6	57·6	31·4	1·66
68	8th Sept.	1030·0	899·0	101·0	25·7	52·3	18·0	2·00
69	14th Sept.	1030·0	883·6	116·4	22·0	52·0	26·4	1·78
70	27th Oct.	1034·0	898·2	101·8	43·0	45·0	14·0	2·74
71	3d Nov.	1032·0	886·0	114·0	45·2	39·2	27·4	2·87
72	11th Nov.	1034·5	914·0	86·0	35·3	39·5	8·0	2·40
73	18th Nov.	1033·0	880·6	119·4	37·0	45·4	34·0	2·50
74	25th Nov.	1033·4	890·4	109·6	38·5	47·5	19·0	2·70
75	1st Dec.	1032·0	902·0	98·0	39·0	49·0	8·0	2·08
76	8th Dec.	1033·0	890·0	110·0	41·0	43·0	22·0	2·76
77	16th Dec.	1034·4	891·0	109·0	42·0	44·0	20·0	2·68
78	31st Dec.	1034·0	861·4	138·6	31·0	52·0	54·0	2·35
79	4th Jan.	1032·0	873·6	126·4	40·0	46·0	37·0	2·70

A glance at the three columns of casein, sugar, and butter, will show that, with few exceptions, 1st, the quantity of casein is at its minimum at the commencement; it then rises considerably, and ultimately attains a nearly fixed proportion; that,

2d, the quantity of sugar is at its maximum at the commencement, and subsequently diminishes; and that, 3d, the butter is a very variable constituent of the milk.

The variations observed in the columns of the sugar and of the casein arise in all probability from those disturbances of the mode of living, and of the tranquillity of the mind, which produce a decided influence on the composition of the milk, and over which the experimentalist can exert no control.

Milk changed by disease.

There are certain morbid states of the system which produce such an influence on the milk that the infant cannot partake of it without detriment to its health. It is a well-known fact that the milk of women who are exposed to violent mental agitation, to passion, grief, &c. will occasionally produce very serious effects (and sometimes even instantaneous death,) on the infant: and some physiologists and physicians are of opinion that chronic diseases may be transmitted by the milk from the mother to the child.

When we read the statements of trustworthy authors regarding the instantaneously fatal effect produced by the milk on the infant, on the occurrence of a sudden shock affecting the mind of the mother, we cannot deny that some chemical change is produced through the nervous influence on the milk, although we cannot determine the nature of that change. In many cases the milk, possibly, acts only as a conducting fluid, and thus conveys the nervous shock from the mother to the child.

Certain morbid changes in the milk which are dependent on the formation of mammary abscess, may be easily recognised by the microscope, which will then reveal the presence of pus- or mucus-corpuscles. Thus in cow's milk which was drawn from a teat affected with vaccinia, I found a considerable quantity of mucus- or pus-corpuscles, while in the milk drawn from another teat of the same udder there were none.

When a mammary abscess opens internally, the milk always contains pus-corpuscles, and frequently also blood-corpuscles, if blood has escaped with the pus. Donné[1] has frequently made

[1] Du Lait, etc. p. 40.

microscopic examinations of the milk of women with swelled breasts; it resembles, in some measure, the colostrum. In the milk of a cow affected with vaccinia, I found a number of corpuscles, which were very like the yellow granulated colostrum-corpuscles.

I have had an opportunity of examining the milk of a recently-delivered woman, who was in a state of considerable fever in consequence of a violent fit of passion: her child, after partaking of her milk, was seized with vomiting, diarrhœa, and convulsions. The breasts were swollen, tense, and painful; the milk had an alkaline reaction, and apparently possessed the qualities of the ordinary secretion; it had, however, a different and not very easily described animal odour. When boiled it exhibited no albumen, but after evaporation to a certain point it coagulated, and had a marked acid reaction. Another portion that was set aside, coagulated after some hours, and had an acid reaction, a circumstance I have never observed in healthy human milk, which will remain undecomposed for five or six days. After twenty hours it developed so large an amount of sulphuretted hydrogen, that a slip of paper which had been moistened in a solution of lead, and was then placed in the flask, in a short time became brown. The casein, sugar, and butter, did not seem to have undergone any change, either qualitative or quantitative. In fact there appeared to be little difference between it and the milk that was secreted twenty-four hours before, and six days later, as may be seen by a comparison of analyses 67, 68, and 69: analysis 68 merely exhibits a smaller proportion of solid constituents, which is principally due to the decrease of butter. The differences observable in this milk were undoubtedly connected with the bad effects which it produced on the infant.

The case was altogether different with the milk of a woman who contracted syphilis after the birth of her first child, and who, in consequence of defective or improper medical treatment, carried the remains of the disease about her for years. The children which she bore while in this condition, and which were begotten by her husband who also had some suspicious sores on the feet, did well for the first half year, they then became highly scrofulous, and died in a state of marasmus: the first child was perfectly healthy. The milk, when she was

suckling her sixth child, which was a year and half old, and in a dreadfully scrofulous state, exhibited no deviation from the healthy secretion: it appeared rich, tasted and smelled like healthy milk, and had an alkaline reaction, which it retained for the space of six days. Its constituents, casein, sugar, and butter, appeared normal, and there was no peculiarity in their quantitative admixture. (See analysis 64, p. 51.) Hence, although the woman was suffering from a malignant chronic disease, no morbid change was observable in the milk.

Donné[1] has frequently submitted the milk of syphilitic women to microscopic examination, but never observed any deviations from the normal appearance.

Meggenhofen[2] found that the milk of a syphilitic woman reddened tincture of litmus, and that it was coagulated by protonitrate of mercury, basic acetate of lead, and infusion of galls, but not by hydrochloric or acetic acid, protochloride of tin, neutral acetate of lead, or alcohol of 0·83.

Herberger[3] has analysed a specimen of diseased human milk; he found it composed of, water, 895; solid constituents, 105; casein, 18·3; sugar, 26·9; butter, 23·3; chlorides of potassium and sodium, lactate and phosphate of potash, and an inorganic substance, insoluble in oil of turpentine, 41·6; organic matter soluble in oil of turpentine, 1·6. The latter substance was a yellow extract soluble in water and alcohol. The solution reduced the salts of gold, silver, and platinum, yielded no ammonia by dry distillation, and was not precipitated by tannic acid.

Deyeux[4] examined the milk of a woman who was liable to frequent nervous attacks: he found that simultaneously with these seizures, the milk became transparent and viscid, like albumen, and did not reassume its normal condition for some time.

Other changes in the milk.

Certain substances which are not included in the ordinary constituents of the milk are sometimes detected in it, after having been taken into the system, either as food or medicine. It is

[1] Op. cit. p. 52. [2] Dissert. inaug. etc. p. 16.
[3] Journal für prakt. Chemie, vol. vi, p. 284.
[4] Crell's Chemische Annalen. vol. i, p. 369.

not to be expected that all the substances which enter the circulating fluid and are separated by the kidneys, should be found in the milk, since the absorbents appear to exert a sort of selective power, and would thus reject those substances which occur in the blood, but which would produce an injurious effect on the tender frame of the infant, if they entered into the milk.

I have sought in vain for ferrocyanide of potassium in the milk of women who were suckling, and to whom I have given it in doses of six drachms. This salt is known to enter very readily into the circulation, and is found after a very short interval in the urine. After the lapse of two days I gave the same woman twenty-three grains of iodide of potassium, but I could detect no trace of this salt in the milk. Lastly, I attempted in vain to detect sulphate of magnesia in the milk of a woman who was suckling, and to whom I had administered it in a sufficient dose to act as a laxative.

For the particulars of these experiments I must refer to my essay 'On the Milk of Woman, in its Chemical and Physiological Relations.' From these observations I think that I am justified in the conclusion that energetic substances, which are foreign to normal milk, either do not enter into that secretion at all, or if they do, they undergo modifications, which render them more compatible with the organism. Although I could not detect the sulphuric acid of the sulphate of magnesia in the milk, it is very probable that the magnesia entered the milk as a lactate, while the sulphuric acid was carried off by the urine as a sulphate.

Peligot, however, has detected iodide of potassium in asses' milk; and Herberger in the milk of woman. [I have on several occasions observed the ordinary indication of iodine on the addition of xyloidin, or of starch and a drop or two of nitric acid to the urine of infants at the breast during the period of the mother taking three grains of hydriodate of potash thrice a day—a convincing proof that the salt has entered the milk.] Mercurial medicines used by women who are suckling have never been traced in the milk, [although their effects on the infant are undoubted.]

OF THE MILK OF ANIMALS.

Colostrum of animals.

In the colostrum of the cow Chevallier and Henri found: water, 803·8; casein, 170·7; and butter, 26·0. They describe it as a dark yellow, thick, viscid fluid, sometimes marked with fine streaks of blood; it has an alkaline reaction, contains little butter, (as shown by the analysis,) coagulates on heating, and in all probability contains a mixture of albumen and casein, in the same manner as I observed in the mammary secretion of the ass a short time before delivery.

Boussingault and Le Bel[1] found in the colostrum of a cow the day after calving: water, 784·0; casein with albumen, 151·0; butter, 26·0; sugar, 36·0; and earthy salts, 3·0. (I shall presently describe a specimen of cow's milk resembling colostrum, which was analysed by me.)

In the colostrum of the ass Chevallier and Henri found: water, 828·4; casein, 123·0; butter, 5·6; and sugar, 43·0;—and in the colostrum of the goat: water, 641·0; casein, 275·0; butter, 52·0; and sugar, 32·0.

The 170·7 parts of casein found by Chevallier and Henri in the colostrum of the cow, consisted of 150·7 of a substance coagulable at a boiling heat, which they termed colostrum-casein, and of 20 of a substance remaining in the whey, to which they applied the name of *matière muqueuse.*

The 123 parts of casein in the colostrum of the ass consisted of 116 of the former, and 7 of the latter substance; and in the colostrum of the goat they were in the proportion of 245 : 30. These numbers approximate very closely to the proportional amount of casein and albumen in asses' milk, previously to delivery. (See page 48.)

1. *Cow's milk.*

Cow's milk is a rich white fluid of an agreeable, somewhat sweetish taste, and of a peculiar odour; when allowed to stand,

[1] Anal. de Chim. et de Phys. May 1839.

the fatty portion (cream) collects on the surface; when boiled, it becomes covered with a film of coagulated casein. My own observations and those of others show that, when fresh, it has always an alkaline reaction. D'Arcet and Petit have, however, found it to be acid. This discrepancy may probably be explained by the circumstance of the speedy conversion of the sugar into lactic acid, which is sometimes noticed in cow's milk. The state of acidity is hastened by a heightened temperature, and is most rapidly induced by being brought in contact with rennet. The specific gravity of cow's milk varies from 1030 to 1035.

We possess several analyses of cow's milk; it has been examined by Herberger and myself by the method I have previously explained, and our results approximate closely. The third of my analyses (No. 82) represents the milk a short time after calving, while it still retained the character of colostrum. Boussingault and Le Bel have also analysed normal milk with the view of ascertaining the influence of various sorts of fodder on its composition; by the adoption of the French method to which I have already alluded, they obtained too little casein and too much sugar. I shall give the mean of twelve of their analyses:

	F. Simon.			Herberger.		Lecanu.	Boussingault and Le Bel.	Chevallier and Henri.
	An. 80.	81.	82.	1.	2.			
Water	857·0	861·0	823·0	853·0	862·0	868	874·0	870·2
Solid constituents	143·0	139·0	177·0	147·0	138·0	132	126·0	129·8
Butter	40·0	38·0	55·0	38·9	37·5	36	39·0	31·3
Casein	72·0	68·0	67·0	69·8	67·0	56	34·0	44·8
Sugar and extractive matter	28·0	29·0	51·0	31·3	26·3	40	53·0	47·7
Fixed salts	6·2	6·1	13·0	7·0	7·2			6·0
Earthy salts							2·2	

[Haidlen found, in the milk of a cow: water, 873; solid residue, 127; butter, 30; casein and insoluble salts, 51; sugar and soluble salts, 46. He has carefully studied the salts of the milk, and is of opinion that the carbonate of soda that occurs in the ash does not originate from a lactate in the fresh milk, but exists there combined with casein. The salts are combinations of phosphoric acid with lime, magnesia, and per-

oxide of iron; chlorides of sodium and potassium, and soda in combination with casein.

The following numbers represent the amount of the various salts found in 1000 parts of milk: the per centage of each constituent is added in order to show the slight variation to which the different salts are liable, in relation to the mass of the ash.

	1.	Per centage.	2.	Per centage.
Phosphate of lime	2·31	47·1	3·44	50·7
Phosphate of magnesia	0·42	8·6	0·64	9·5
Phosphate of peroxide of iron	0·07	1·4	0·07	1·0
Chloride of potassium	1·44	29·4	1·83	27·1
Chloride of sodium	0·24	4·9	0·34	5·0
Soda	0·42	8·6	0·45	6·7
	4·90	100·0	6·77	100·0]

Berzelius[1] found, in skimmed milk: water, 928·75; casein, with butter, 26·00; sugar, 35·00; alcohol-extract, with lactic acid and salts, 6·00; chloride of potassium, 1·70; alkaline phosphates, 0·25; phosphates of lime and magnesia, with traces of iron, 2·30. The cream consisted of: water, 920; butter, 45; casein, 35.

Pfaff and Schwartz[2] estimate the fixed salts at 0·3742%, scarcely more than half the quantity obtained by Herberger and myself. They contained phosphate of lime, 0·1805; phosphate of magnesia, 0·0170; phosphate of iron, 0·0032; phosphate of soda, 0·0225; chloride of potassium, 0·1350; and lactate of soda, 0·0115.

A comparison of my analyses of cow's milk with those of woman's milk will show that the former contains the larger amount of solid constituents, especially of casein, while the latter contains the greater quantity of sugar.

2. *Asses' milk.*

Asses' milk is a tolerably rich white fluid, with a sweeter taste than cow's milk, and occasionally having an acid reaction. Its specific gravity fluctuates between 1035 and 1023. I found

[1] Thierchemie, p. 701.

[2] Diss. inaug. sist. nova experim. circ. lact. princip. constit. Kiel, 1833.

the milk of an ass, about a year after foaling, to be composed of:

	Analysis 83.
Water	907·00
Butter, with some lactic acid	12·10
Casein	16·74
Sugar, with extractive matter and alkaline salts	62·31

The following is the mean of several analyses of asses' milk made by Peligot;[1] his numbers approximate pretty closely to mine:

Water	904·7
Butter	12·9
Casein	19·5
Sugar, extractive matter, and salts	62·9

Chevallier and Henri found in 1000 parts of asses' milk:

Water	916·3
Solid constituents	83·5
Butter	1·1
Casein	18·2
Sugar	60·8
Salts	3·4

Asses' milk contains a smaller amount of solid constituents, especially of casein and butter, than cow's milk; it also differs from it in its great abundance of sugar and extractive matter, in which peculiarity it resembles woman's milk.

3. *Mare's milk.*

Mare's milk is very rich in solid constituents; it has a specific gravity of 1034·6—1045·0; it contains little butter, but a large amount of sugar. Stipriaan, and Luiscius and Bondt obtained from it 0·8% of cream, 1·62% of casein, and 8·75% of sugar. I obtained a yellow, viscid, saltish, and nearly inodorous fluid from the teats of a mare expected to foal shortly: it coagulated on heating, exhibited a few fat-vesicles and granular corpuscles under the microscope, and acetic acid separated a small quantity of casein. It contained 5% of solid constituents, of which only 0·15% was butter. The solid constituents consisted for the most part of albumen, mixed with a little casein, butter, and extractive matter.

[1] Annal. de Chimie et de Physique, Août 1836, p. 432.

4. *Goat's milk.*

Goat's milk is a very rich white fluid, of specific gravity 1036, with a peculiar disagreeable odour arising from the hircic acid which is present in the butter. Its solid constituents are as abundant as those of cow's milk, and it contains in 1000 parts :

	Chevallier and Henri.	Clemm.	Boysson.	John.	Payen.	Stip., Luisc., and Bondt.
Water	868·0	865·175	892·8	849·3	855·0	744·4
Butter	33·2	42·507	29·9	11·7	40·8	45·6
Casein	40·2	60·321	52·9	105·4	45·2	91·2
Sugar	52·8 }	44·065	20·7	23·4		43·8
Salts	5·8 }					
Residue of whey					58·6	
Cream						75·0

[An analysis of the mammary secretion of a he-goat has been recently made by Schlossberger.[1] The animal was four years old, and had given undoubted proof of his generative powers. The fluid obtained by repeatedly milking the animal, had the colour, consistence, and taste of milk, and was perfectly devoid of any unpleasant odour. Under the microscope, the globules appeared numerous, and a considerable amount of cream separated after standing for some time. The milk was analysed according to Haidlen's method, and found to contain :

Water	850·9
Butter	26·5
Casein (with salts insoluble in alcohol)	96·6
Sugar (with salts soluble in alcohol)	26·0

The milk left ·782$\frac{0}{0}$ of ash, of which ·325 were soluble, and ·457 insoluble in water. This case is interesting in reference to the theory of secretion; it seems to show that the secretion of milk is independent of any peculiar condition of the blood incident to pregnancy, but that it depends far more upon the development of the secreting organ.]

[1] Annalen der Chemie und Pharmacie, 1844.

5. *Ewe's milk.*

Ewe's milk is an extremely rich, thick, white fluid, with an agreeable smell and taste, and having a specific gravity of 1035 to 1041. Stipriaan, Luiscius, and Bondt found in 1000 parts:

Water	632·0
Solid constituents	368·0
Butter	58·0
Casein	153·0
Sugar	42·0
Cream	115·0

We cannot help thinking that in this, as well as in the previous analysis by the same chemists, the amount of solid constituents, and especially of the casein, is higher than is likely to be correct. Chevallier and Henri found in 1000 parts:

Water	856·2
Butter	42·0
Casein	45·0
Sugar	50·0
Salts	6·8

6. *Bitches' milk.*

I have made two analyses of the milk of a bitch of the bull-dog breed. The milk was drawn from one of the teats that was not used by the pup: it was very thick, (whereas the milk from the teats which the pup was in the habit of sucking was very thin,) had a disagreeable animal odour, and a rather saltish, mawkish, but not sweet taste. A period of ten days elapsed between the two analyses.

	Anal. 84.	Anal. 85.
Water	657·4	682·0
Solid constituents	342·6	318·0
Butter	162·0	133·0
Casein	174·0	146·0
Extractive matter and traces of sugar	29·0	30·0
Fixed salts	15·0	14·8

This milk is distinguished from every other kind of milk that I have examined, by the immense amount of its solid constituents, and by the nearly total absence of sugar.

[Clemm examined the milk of a bitch. Its specific gravity was 1033; and 1000 parts yielded 274·689 of solid constituents, consisting, for the most part, of casein and butter, but still giving undoubted indications of the presence of a very small quantity of sugar. The bitch was fed entirely on flesh.]

On diseased milk in animals.

The changes produced by disease have been especially studied in cow's milk. The milk may contain mucus, pus, and blood, under similar conditions to those which we have noticed in woman's milk. (See page 57.) These substances are easily detected by the microscope.

Through the kindness of Dr. Bremer, I obtained some milk from the udder of a cow affected with vaccinia, and indeed one portion of the milk was taken from a teat covered with the eruption, while the rest was drawn from a healthy teat. The two specimens differed both chemically and physically: the milk from the diseased teat was strongly alkaline, had a slightly saline taste, and exhibited under the microscope a number of mucus- and pus-corpuscles. It became gelatinous on the addition of a spirituous solution of caustic ammonia; it yielded a precipitate of mucus- or pus-corpuscles on standing, while the upper portion became clear; and it coagulated on heating, in consequence of the presence of albumen.

The milk from the healthy teat had a mild acid reaction, tasted like ordinary milk, contained no pus- or mucus-corpuscles, but a larger proportion of fat-vesicles than the diseased milk. These analyses gave:

	Analysis 86. Milk from the healthy teat.	Analysis 87. Milk from the diseased teat.
Water	912·10	935·40
Solid constituents	87·90	64·60
Butter	19·58	12·05
Casein	40·62	
Casein, with pus or mucus, and albumen		31·40
Sugar, with alcohol-extract, lactates, and chloride of sodium	29·36	
Extractive matter, with chloride of sodium, lactate of soda, and a little sugar		16·18
Water-extract		0·32
Salts soluble in water	3·87	6·42
Salts insoluble in water	3·20	2·42

The great increase of the soluble salts, especially of the free alkali, the presence of albumen, and the almost total absence of sugar, are the points most worthy of notice in the morbid specimen.

Herberger[1] has analysed the milk of cows suffering from the grease, and found it materially affected. In the first stage of the disease he found that the milk only coagulated imperfectly on the addition of rennet, in consequence of the increased quantity of alkaline salts; moreover (and probably for the same reason) the fat-vesiclesw ere not distinct, as they usually are, but merged into each other. In the second stage, only a few fat-vesicles were observable, the coagulation by rennet was very imperfect, and the milk, which was thick and viscid, had an unpleasant putrid smell and taste. In both stages the sugar and casein were below their normal proportions, but the amount of salts was increased; the presence of carbonate of ammonia (an ingredient never before observed in the milk) was detected. His analyses gave the following results:

	In the first stage.		In the second stage.		Healthy milk.
	1.	2.	1.	2.	
Water . .	869·0	872·4	874·1	879·3	857·5
Solid constituents	131·0	127·6	125·4	120·7	142·5
Fat . .	39·0	38·5	38·2	37·9	38·2
Casein . .	52·4	51·0	50·0	49·0	68·4
Sugar . .	22·8	21·0	21·0	19·0	28·8
Fixed salts .	16·8	17·1	16·6	13·9	7·1
Specific gravity	1033·6	1033·0	1033·1	1029·1	1033·7

The most striking changes in the diseased milk are the diminution of the solid constituents, especially of the casein and sugar, and the extraordinary increase of the salts. Hence the modifications of the fluid in this instance closely resemble those in my analyses in the preceding page.

Donné found that the milk of the cow during "la maladie aphtheuse," resembled colostrum. It was less fluid and homogeneous in its mixture than ordinary milk; it became viscid on the addition of ammonia, and, besides the ordinary milk-corpuscles, the microscope revealed mucus-granules and tubercular (mulberry-form) corpuscles.

[1] Pharm. Centralblat. Jahrg. 1840, p. 138.

Of other changes in the milk.

The passage of various substances into the milk has been more frequently observed in animals than in the human species. Peligot detected iodide of potassium, and chloride of sodium in the milk of the ass, after internal administration. The salts of iron, zinc, and bismuth, are also said to enter it in minute quantities.

The sulphates of soda and potash, sulphuret of potassium, and the mercurial salts have never been met with in the milk. The smell, taste, and colour of vegetable substances are taken up by it.

The milk is sometimes observed to become blue on its surface after standing for 24 to 48 hours, and the tint gradually diffuses itself through the whole fluid: the milk has also been observed to turn yellow in a similar manner. Fuchs[1] has carefully investigated this phenomenon, and has detected in milk of this nature a peculiar infusorium, to which he has applied the name *vibrio cyanogenus;* it is not of a blue colour itself, but it appears to have the power of gradually changing the milk to this tint. When removed from the milk, and placed in an infusion of marsh-mallows, these animalcules increase in size, and communicate a faint blue tinge to the fluid; in this way they may be preserved for a long time. Closely allied to this animalcule is the *vibrio xanthogenus;* they are sometimes found together in milk, and Fuchs had also an opportunity of observing them in milk which had become yellow, a much more rare change than the former.

[1] Beiträge zur näheren Kenntniss der gesunden und fehlerhaften Milch der Hausthiere. Magazin für die gesammte Thierheilkunde, Jahrg 7, Stück 2.

CHAPTER V.

SECRETION OF THE MUCOUS MEMBRANE.

Mucus.

All the internal parts of the animal body which are connected by direct continuity with the external surface, are covered by a soft velvety and highly vascular coat—the mucous membrane, which in its turn is protected by a delicate layer of epithelium.[1]

The mucous surfaces, especially when they are in a state of irritation, secrete a viscid, stringy, and often tough fluid; occasionally it is clear and colourless, but most commonly it is turbid, of a faint yellow or grayish white colour, and is frequently of sufficient consistence to separate in gelatinous globular masses, or tough flocculi.

Of normal mucus.

The transition from healthy to diseased mucus is so indefinitely characterized, that it is almost impossible to draw a strict line of demarcation between them, and the same remark is equally applicable to the further change of the diseased secretion into pus: hence it is not very easy to form a distinct conception of what normal mucus really is.

Henle states that in the same manner as the outer surface of the external skin is continually peeling off and giving place to

[1] According to Henle the epithelium consists of one or more layers of cells which, from the peculiarity of their form, are arranged in three groups: 1st, Pavement epithelium [the scaly epithelium of Bowman], fig. 14 *a*, which occurs in the mouth, in the intestinal canal as far as the pylorus, in the vagina, &c.: 2d, Cylinder epithelium, [the prismatic of Bowman, the columnar of Todd,] fig. 14 *b*, having a conical form, and arranged perpendicularly to the basement membrane; this form occurs in the portion of the intestinal canal below the pylorus, in the gall-bladder, and in the male genito-urinary apparatus: and 3d, The ciliated epithelium, fig. 14 *c*, which resembles the cylinder epithelium in form, and has its free edges armed with cilia. This occurs in the respiratory organs, in the uterus, and fallopian tubes.

the layer beneath it, so there is also a continuous desquamation or separation of the epithelium of the mucous surfaces, which sometimes occurs in men, who are in other respects healthy, to such an extent that thick clots of mucus are expectorated in the morning; which, on being examined with the microscope, contain merely epithelium-cells. This, which is formed by a mere act of separation from the uppermost layer of epithelium, is regarded by Henle as normal mucus: he gives it the name, however, of epithelium, and restricts the term mucus to the morbid secretion of the mucous surfaces in which mucus-corpuscles (of which I shall speak presently) are found. I have always found these corpuscles in the secretion from the nasal and pulmonary mucous membrane of perfectly healthy persons: they are mixed in a small quantity with the epithelium-cells, and become increased when the mucous membrane is irritated.

Physical character of mucus.

Normal mucus, when fresh and recently secreted, is denser than water, and when mixed with that fluid it gradually sinks to the bottom of the vessel, unless it should be hindered from doing so by extraneous causes.

Dried mucus sinks very rapidly: normal mucus from the lungs or nostrils usually floats on water for a considerable period; in fact it was regarded as characteristic of mucus to float on water, in contradistinction to pus, which always sinks. A more careful investigation enables us to trace the floating of the mucus to two causes: first to the number of air-bubbles that are entangled in it, (after the removal of which it sinks); and, secondly, to the proportionally small amount of solid constituents in the secretion. The insolubility of fluid mucus in water is the cause of the long retention of the air-bubbles. When mucus contains pus, the proportion of solid constituents increases, the fluid portion diminishes, and its place is supplied by albumen. Water rapidly permeates mucus in this state, the air-bubbles escape, and it speedily falls to the bottom in consequence of its specific gravity. Mucus from the bladder or from the intestines does not swim on water in consequence of the absence of air-bubbles.

When some fresh, fluid, transparent, nasal, or bronchial mucus

is examined under the microscope, it is found to consist of a liquid in which minute rounded or prolonged corpuscles of a granular appearance (mucus-corpuscles) are inclosed, which do not exhibit any independent motion, in consequence of the thick viscid nature of the fluid in which they are suspended; but when the fluid is stirred they are seen to move with it. In addition to the mucus-corpuscles, some epithelium-cells are also observed, and a finely-granulated substance which pervades the whole fluid, and can only be seen with a good light. Nasal mucus, from my own observations, is represented in fig. 15; *a a* mucus-corpuscles, *b b* epithelium cells; *c c* the faintly granular substance.

According to Henle, the diameter of the mucus-corpuscles varies from 0·003 to 0·007 of a line: according to Vogel, from 0·004 of a line: Gruby[1] considers them from 2 to 4 times the size of the blood-corpuscles. They are prolonged, oval, or round, and when observed in fresh mucus have a clear well-defined contour, a pale gray colour, a granular appearance, and sometimes give faint indications of one or more nuclei. After remaining for some time in water, the mucus-corpuscles become more or less swollen, paler, and more transparent; the granular appearance on the external capsule disappears, and one or more nuclei may be observed in the interior of the cell. The external capsule frequently becomes so colourless as to render its detection difficult.

The epithelium-cells appear under the microscope in the form of elliptic discs; according to Gruby, the axis major varies from 0·013 to 0·0333 of a line, and the axis minor from 0·010 to 0·016 of a line: the surface is frequently irregular, wrinkled, or plicated. We sometimes find them swollen and vesicular, and sometimes, but more rarely, almost circular or elliptic. The nucleus is of the same prolonged form as the mucus-corpuscle; it is granular and rather darker coloured. If mucus is frequently observed, the transition of mucus-corpuscles into epithelium-cells may easily be seen. We have attempted to illustrate this progressive change in *d, e, f,* fig. 15.

[1] Observationes Microscopicæ ad Morphologiam Pathologicam. Vindobonæ, p. 15.

Chemical character of mucus.

The action of chemical reagents on the epithelium cells and mucus-corpuscles may easily be observed under the microscope. The former are not affected by the addition of water or of dilute acids; they disappear, however, under the influence of caustic alkalies or concentrated acids. According to Gruby, solutions of the ordinary earthy, and metallic salts effect no change on the epithelium cells. The mucus-corpuscles are very differently acted on. Dilute acetic, oxalic, and tartaric acids speedily deprive the capsules of the mucus-corpuscles of their granular appearance. The corpuscles themselves become round and transparent; the nuclei become apparent, the capsules at length disappear, and the nuclei frequently divide into several granular bodies, so that in place of the mucus-corpuscles previously visible, there are at last only two, three, or more rounded granules to be seen.

Dilute mineral acids do not produce these changes in the capsule of the mucus-corpuscle, which remains unchanged, as shown by the observations of Güterbock, Vogel, Gruby, and myself. Dilute, as well as concentrated solutions of the alkalies and their carbonates render the capsules clearer, and ultimately dissolve them. The free fixed alkalies produce these changes more rapidly than their carbonates; free ammonia much less rapidly than free potash.

The liquid portion of the mucus always exhibits a decidedly alkaline reaction: when examined under the microscope it appears like a clear fluid, in which, with a very good light, a faint granular appearance is perceptible. On the addition of a little water, a decided coagulation may be observed, and an extremely fine granular precipitate is formed. Acetic, and indeed any weak acid produces a similar effect, but the precipitate is more copious, and forms a grayish granular film, sufficiently strong to admit of traction. The free alkalies and their carbonates do not precipitate this fluid.

It is clear from the preceding observations that mucus is composed of two distinct parts, the cells and the fluid. The viscidity of the secretion evidently pertains to the latter, and the ingredient that gives rise to this property must be contained

in it in a state of solution, as is obvious from microscopic examination. There can, I conceive, be no doubt that the principal constituent of the fluid, *mucin*,[1] is held in solution by means of an alkali, since water (by taking up the alkali) is sufficient to precipitate it, and the effect is produced in a much higher degree by the addition of a free acid.

When mucus is allowed to remain in contact with water, a slight quantity of the mucin always dissolves, probably through the aid of a free alkali; hence it is that the water in which the sputa, during catarrhal affections, are allowed to float, always become slightly turbid on the addition of acetic acid.

In addition to the mucin, the fluid portion of the mucus also contains a small quantity of extractive matters and salts, (especially lactate of soda and chloride of sodium,) and either no albumen, or at any rate a mere trace. The contents of the mucus-corpuscles are not accurately known; in all probability they contain a fluid in addition to their nuclei. The fat that occurs in mucus is probably contained in the corpuscles, for no fat-vesicles are generally observed in fresh mucus, but after the solution of the corpuscles by the addition of acetic acid, a few fat-vesicles make their appearance; indeed in some of my observations, the nuclei of the mucus-corpuscles, have seemed to lose their dark granular appearance, and, after a time, to become clear and like minute fat-vesicles. The nuclei of mucus-corpuscles do not appear to undergo this change invariably; there are probably different stages of development, and on the assumption that the nuclei of the least-developed corpuscles are composed of fat, the relative increase of fat will clearly correspond with the amount of mucus that is secreted.

[1] [Simon observed the great similarity between mucin and pyin; the researches of Eichholtz seem to show that these substances are identical. The substance described by Eichholtz as pyin differs from the protein-compounds in being precipitated from an alkaline solution by an aqueous solution of iodine and by distilled water. A considerable excess of water dissolves a slight portion of it. Dilute mineral acids, when carefully added, precipitate it, but when in slight excess, immediately redissolve it; moreover, ferrocyanide of potassium causes no precipitate in a clear acid solution, but a turbidity is produced by the same substances that throw it down from its alkaline solutions. Acetic, tartaric, and oxalic acids precipitate, but do not redissolve it, and a solution of alum, gradually added, produces a precipitate insoluble in an excess of the test. On evaporating an alkaline solution of mucin on the water-bath, it becomes covered with a film of coagulated mucin which is difficult of solution in water.]

It follows, from the preceding observations, that mucus contains the following constituents: mucus-corpuscles, epithelium cells, mucin, small quantities of extractive matters and fat, chlorides of sodium and potassium, alkaline lactates, a little carbonate of soda and phosphate of lime, and sometimes a minute quantity of albumen. In order to separate these constituents I adopt the following course.

A known weight of mucus must be washed with distilled water and evaporated to dryness on the water-bath. The residue must be finely triturated and repeatedly extracted with boiling ether in order to remove the fat; it must then be boiled in spirit of 0·91 as long as any additional matter is dissolved. The spirituous solution must be evaporated to a small syrupy residue, and alcohol of 0·85 added, in order to precipitate any dissolved mucin, caseous matter, water-extract, and pyin: the alcoholic solution, containing the alcohol-extract and lactates, is also to be evaporated. The portion undissolved by boiling spirit of 0·91, consists of mucin with cells, and traces of albumen, if the previous qualitative investigation has shown that this substance is present.

In order to determine the salts, a portion of the dried residue must be submitted to incineration. It is difficult to obtain a white ash in consequence of the fusion of the salts. The chlorides may be extracted with spirit; the residue must be then treated with acetic acid, in order to convert the carbonates, which have arisen from the incineration of the alkaline lactates, into acetates, which may be extracted with alcohol. Anything that still remains, is composed of phosphates and perhaps sulphates, in very minute quantity, together with traces of iron and silica.

I have analysed mucus both from the nose and lungs, during pulmonary catarrh, but as I cannot regard these cases as illustrations of normal mucus, I shall defer their consideration for the present. From an analysis of nasal mucus made by Berzelius, it appears that there are in 1000 parts:

Water	933·7
Mucin	53·3
Alcohol-extract and alkaline lactates	3·0
Chlorides of sodium and potassium	5·6
Water-extract with traces of albumen and phosphates	3·5
Soda, combined with mucus	3·9

Consequently Berzelius found no fat, but he detected traces of albumen.

The foregoing remarks refer especially to the mucus of the nostrils and lungs, but as the physico-chemical properties of all sorts of mucus are not quite the same, I shall briefly communicate my own observations and those of Berzelius on the different varieties of mucus.

1. *Nasal mucus.*

Nasal mucus generally occurs as a gelatinous or fibrous, and nearly transparent mass; after complete evaporation it remains in the basin as a yellow, and tolerably transparent coating. It contains epithelium cells and a few mucus-corpuscles, is not soluble in water, but if it remains in contact with that fluid for a considerable time it yields some mucin, in consequence of which the addition of acetic acid to the water produces a very slight turbidity. When water containing mucus is submitted to filtration, the latter remains on the filter and gradually solidifies. Berzelius has observed that it may be dried and again diffused through water repeatedly, without changing its properties; it ultimately, however, becomes opaque, yellow, and apparently purulent. When boiled with water it does not shrivel and harden, but only slightly contracts, and may be diffused by shaking. On cooling, it again becomes tenacious and viscid. By dry distillation of evaporated mucus we obtain carbonate of ammonia and Dippel's oil. Mucus dissolves in dilute sulphuric acid; in the concentrated acid it becomes dark coloured and is decomposed. Dilute nitric acid causes a superficial coagulation; acetic acid induces a degree of contraction, and the mucus does not dissolve in it at a boiling heat. On the addition of caustic alkalies, it, at first, becomes tough and thick, but subsequently dissolves into a thin fluid.

2. *Bronchial and pulmonary mucus.*

These are very similar to nasal mucus. They separate into clear and gelatinous, or else into gray or yellowish flocculi, which remain suspended in water for some time, but ultimately sink to the bottom.

[Nasse[1] has analysed pulmonary mucus expectorated in the morning by a healthy man. Analysis No. 1 refers to the mucus itself, and No. 2 to the solid residue.

	1.	2.
Water	955·520	
Solid constituents	44·480	
Mucin, with a little albumen	23·754	53·405
Water-extract	8·006	18·000
Alcohol-extract	1·810	4·070
Fat	2·887	2·490
Chloride of sodium	5·825	13·095
Sulphate of soda	0·400	0·880
Carbonate of soda	0·198	0·465
Phosphate of soda	0·080	0·180
Phosphate of potash, with traces of iron	0·974	2·190
Carbonate of potash	0·291	0·655
Silica, and sulphate of potash	0·255	0·570]

3. *Mucus from the intestinal canal.*

When evacuated with watery motions after the administration of a purgative, I found it occurring in yellow gelatinous masses, which, on being examined with the microscope, were observed to contain a large quantity of mucus-corpuscles. Berzelius found that the mucus discharged with the fæces becomes hard and black on drying; if it is then placed in water it becomes softer, and if the water contains any free alkali it again becomes viscid. It is thoroughly soluble in caustic potash, and it may be precipitated from its alkaline solution by the addition of any acid. According to Gmelin,[2] the mucus from the small intestines of dogs and horses appears, after being washed in cold water, in the form of white shreds or flocculi. Dilute acids increase its coagulation, but concentrated acetic acid dissolves the greater part. It also dissolves in the alkalies, from which it may be precipitated by an acid.

4. *Mucus from the gall-bladder.*

When bile is submitted to filtration a certain quantity of mucus which is suspended in the bile is detained on the filter, while another portion chemically combined with an alkali passes through in a state of solution, and may be precipitated by

[1] Journal für praktische Chemie, vol. 9, p. 59.
[2] Handbuch der theoretischen Chemie, vol. ii, p. 1118.

an acid: the latter has, however, lost the characteristic viscidity of mucus. If the acid be removed by means of an alkaline carbonate, the mass does not become viscid; if, however, instead of a carbonate, a caustic alkali is employed, the viscidity is restored. If the mucus of the gall-bladder is precipitated by alcohol, the viscidity disappears, it is restored, however, by being washed in water. When dried, it becomes transparent and yellow; on the addition of water it swells, and is rendered opaque but not viscid.

5. *Mucus from the urinary bladder.*

Vesical mucus is always present in the urine, but only in very small quantity in the normal secretion. In recently discharged urine it cannot be detected with the naked eye, but after the fluid has stood for some time, there are formed light, often hardly perceptible nebulæ of sinking mucus, in which the microscope reveals mucus-corpuscles and epithelium-cells. On filtration the mucus remains on the paper in the form of colourless flocculi; it contracts and ultimately forms a glistening varnish-like coating, which does not resume its former appearance on being moistened with water.

According to Berzelius it is insoluble in sulphuric acid, but the greater part of it dissolves in acetic and hydrochloric acids: ferrocyanide of potassium throws down a precipitate from these solutions.[1]

Morbid Mucus.

It is well known that any irritation will increase the secretion of mucus in an extraordinary degree; this is seen in the secretion of the mucous membrane of the nostrils and lungs during a common cold or catarrh. The mucus is then materially changed; at the commencement of the attack it is gene-

[1] [We have at present analyses of only three varieties of mucus, viz. the mucus of the oviduct of frogs, the mucus of the œsophagus of the peculiar species of swallows which build edible nests, and the mucus of the gall-bladder. The results differ so much that either animal mucus is a variable mixture of heterogeneous substances, or that different substances at present bear the name of *mucus* in common. The analyses are quoted in Mulder's Chemistry of Vegetable and Animal Physiology, p. 240, English translation.]

rally thinner than usual; but, towards the termination, it becomes thicker; the epithelium-cells diminish, while the mucus-corpuscles increase in number; the reaction continues alkaline; in fact, in most cases it is more strongly so than in the normal state; the fat is increased, and always contains cholesterin; and at the same time there is an excess of albumen.

Gruby found that mucus secreted by the nasal mucous membrane during a state of irritation of that surface, was white, of the consistence of the white of eggs, and had a saline taste. When examined with the microscope, there were only a few epithelium-cells and mucus-corpuscles to be seen.

I have analysed nasal mucus which accumulated in the upper part of the nose of a man aged thirty years; it generally came away in the form of thick, tough, yellow lumps, about the size of an ordinary bean, or, if it had only been retained in the nostril for a shorter period, it was obtained as an extremely copious, tough, yellow fluid; it was invariably discharged from only one nostril. This mucus was devoid of odour, had an alkaline reaction, and being moistened with water, (in which it sank,) it exhibited an extraordinarily large quantity of epithelium-cells, and a few mucus-corpuscles, connected by a pretty thick membrane of coagulated mucin. When the mucus was gently dried and pressed between the fingers, they presented the same glistening appearance as if they had been pressing fat; no fat could, however, be distinctly recognised by the microscope in consequence of the dense strata of membrane and mucus-corpuscles. In 1000 parts of this mucus there were contained:

	Analysis 88.
Water	880·0
Solid constituents	120·0
Fat, containing cholesterin	6·0
Caseous matter, with pyin or mucin in solution	13·2
Extractive matters, with lactates and chloride of sodium	12·0
Albumen, cells, and coagulated mucin	84·0

Gruby found that the mucus secreted during catarrhal affections (slight inflammation) of the mucous membrane of the nose, conjunctiva, fauces, larynx, bronchi, ureters, vagina, and intestinal canal is thicker than the mucus secreted during mere irritation of those membranes; it was thick, tough, lubricous, of a yellowish white colour, and, as it gradually dried, it formed a grayish-yellow elastic mass. It sank in water,

unless air-bubbles were entangled in it, and exhibited no change for a considerable time, but ultimately became whiter. With the aid of the microscope, Gruby observed, 1st, a white amorphous mass, not acted on by water (coagulated mucin,) and 2d, round yellowish-white globules, whose number seemed in a direct ratio with the intensity of the yellow colour of the mucus. These cells which were observed in the mucus of the larynx, had eight times the diameter of the blood-corpuscles, were intimately connected with the amorphous white mass, and consisted of a very delicate transparent capsule that was easily ruptured, of an inner round cell with a nucleus twice as large as a blood-corpuscle, and very many small vesicles one sixth the diameter of the blood-corpuscles, some of which were transparent and some opaque. The large vesicles sometimes contained two inner central cells.

I have also frequently observed these large cells (which strongly resemble the full primary cells described and figured by Henle,[1]) in the gray or yellow-streaked gelatinous mucous flocculi which are expectorated during a slight catarrh of the trachea and bronchi, as well as in the thick, tough, yellow nasal mucus that is secreted during a cold. I have represented this bronchial mucus in fig. 16, in which *aa* represent the large cells. Other observers have detected these cells in tubercular matter; it is clear, however, that they occur in diseased mucus, and are not to be regarded as diagnostic of tubercle.

Gruby found that the mucus in ophthalmoblennorrhœa, and in the uterine and vaginal discharges of some women after their confinement, is of a deep yellow colour, thready and opaque; it sinks in water and forms flocculi, which, on being stirred, discolour the fluid; but after remaining in the water for some time, they lose their power of communicating their colour to a fresh supply of clear water. This mucus, when dried, forms a yellow, transparent, brittle mass, which continues to burn when lighted. Under the microscope, a white amorphous mass, insoluble in water, is observed, together with a large number of yellow vesicles of the form and nature of those previously described, some with, and others without a central cell. These vesicles swell in water, the capsule bursts, the inclosed molecules escape, and

[1] Ueber Schleim und Eiterbildung u. s. w. fig. 14.

either become scattered or else accumulate round the unchanged internal cell, and often exhibit for some time the phenomena of molecular motion. Only a few epithelium-cells are observable; those that are present are full, round, and often closely resemble the large mucus-vesicles. I have likewise observed these epithelium-cells, which I regard as characteristic of a lower stage of development, in nasal mucus. (See fig. 14, *d, e, f.*)

The mucus secreted in chronic blennorrhœa of the vagina and bladder is, according to Gruby, of a yellowish white colour, and slightly thready. It quickly renders water turbid, and deposits white flocks at the bottom of the vessel: in other respects it resembles the former varieties of mucus. Under the microscope we observe a small number of yellowish white vesicles, some with a capsule, granular contents, and a central cell, some with merely a capsule and a central cell, and some that are composed of an aggregation of granules, without any capsule whatever.

Gruby found that the lochial discharge,[1] a short time after delivery, is of the colour of blood, is possessed of an animal odour, is only slightly thready, and when dried leaves a red pulverisable mass; it consists of hæmatoglobulin, fibrin, (probably also albumen,) and vaginal mucus: under the microscope we observe an amorphous thready mass, blood-corpuscles, mucus-vesicles with capsules and aggregated granular molecules, and finally epithelium-cells. Very shortly before delivery we can observe nothing in the vaginal mucus beyond the true mucus-corpuscles (fig. 14, *a*,) and epithelium-cells; but very soon after delivery the large mucus-vesicles, with granular contents (molecular granules) and delicate capsules, make their appearance. Fig. 16, *a*, exhibits these cells, and is copied from the plate in Gruby's work. On the second day after delivery vesicles with a central cell (fig. 16, *b*) are visible, the mucus becomes less dense, the blood-corpuscles diminish, and the large mucus-vesicles increase in number. On the third day the reddish lochial discharge contains yellow vesicles with granular contents and central cells. On the fourth day the discharge is considerably less red, and contains white stringy flocculi. On the fifth day the mucus contains grayish white, viscid flocculi,

[1] Scherer's observations on this subject have been already given: see Vol. I, p. 338.

together with white vesicles, eight or ten times the size of blood-corpuscles, which contain only a few, and, in some cases, no granular molecules; these are represented in fig. 16, *c, d*. Between the sixth and tenth days the lochial discharge becomes white, and contains white round vesicles, with finely granular contents, but devoid of a central cell, or the larger molecules. (Fig. 16, *e, f, g*.)

Gruby has shown that the mucus discharged by stool at the commencement of dysentery is clear and stringy, and scarcely different from the mucus secreted in simple diarrhœa, but as the disease becomes more severe, there is a secretion of thick red mucus, consisting of blood- and mucus-corpuscles, resembling the ordinary secretion of inflamed mucous membranes.

I have observed that the mucus secreted during inflammatory affections of the mucous membrane of the respiratory organs is thick, rounded in form, of a white or pale yellow colour, and floats on water. These clots of mucus remain unbroken for a considerable time, but ultimately break up, and sink to the bottom: they then spread out into long tough fibres, which, when observed with the naked eye, have an uniform non-granular appearance: they possess a certain degree of consistency, and feel slippery, in consequence of the mucin which connects the mucus-corpuscles; they are consequently not very easily fixed and broken up by pressure against the sides of the vessel with a glass rod. When examined with the microscope, the white masses of mucus are found to consist of a large number of mucus-corpuscles, and a few epithelium-scales, connected by a delicate granular membrane of coagulated mucin: the yellow clots contain, in proportion to the intensity of their colour, a greater or smaller quantity of the large cells with granular contents, (fig. 16, *aa*,) in some of which a central cell is visible, while in others no cell can be seen. The fluid in which the thick clots of mucus are swimming is slightly clouded by acetic acid, but rendered very turbid by nitric acid: on the application of heat, it becomes white and opalescent; and infusion of galls, and basic acetate of lead yield tolerably copious flocculent precipitates; there is, consequently, a greater quantity of dissolved mucin and albumen present than the water would have extracted from healthy mucus. A quantitative analysis of these floating clots, after being well washed in distilled water, gave the following results.

The numbers are calculated for 1000 parts :

	Analysis 89.
Water	941·75
Solid constituents	58·25
Fat with traces of cholesterin	5·01
Spirit-extract, with lactates and chloride of sodium	11·09
Alcohol-extract	6·95
Cells, mucin, and a little albumen	34·80

In a case of severe bronchitis that recently occurred in Schönlein's clinical wards, the patient expectorated purulent mucus, which, when placed in water, assumed a delicate arborescent form, the ultimate fibrils floating on the water when the slightest motion was communicated to the vessel. When placed in acetic acid, it swelled and became converted into a transparent jelly, and after long digestion almost entirely dissolved; the solution being precipitable by ferrocyanide of potassium. Under the microscope the fibrils resembled coagulated fibrin, and there can be no doubt that plastic lymph was exuded as a consequence of the bronchitis, and expectorated in a coagulated form. [Observations on the sputa in bronchitis and pneumonia may be found in Scherer's 'Untersuchungen,' pp. 93-97.]

Gruby states that the sputa expectorated during the ordinary inflammatory affections of the mucous membrane of the respiratory organs, are, at the commencement of a catarrh, white, transparent, and mixed with gray flocculi; under the microscope they are seen to contain a few round vesicles with granular contents, and numerous epithelium-cells, swimming in a transparent fluid. As the catarrh gets worse, the gray flocculi increase, and become more of a yellow colour, and the amount of transparent mucus decreases; the coloured flocculi contain numerous cells with granular contents (molecular granules) and a central cell, which are all connected together by very tough mucus. As the inflammation decreases the amount of this globular sputa diminishes, and it assumes a whiter colour.

Purulent Mucus.

If the mucous membranes or the tissues immediately beneath them pass into a state of suppuration, pus becomes mixed with the secreted mucus: in this manner the mucus of the lungs, bladder, intestinal canal, generative organs, &c. may contain

pus. When tubercles form in the lungs, they produce, like any other foreign body, a degree of irritation in the surrounding tissue, and an increased secretion of mucus is the result. Gruby's observation that the mucus discharged during irritation of the mucous membrane, dependent on the deposition of tubercle, does not differ from the mucus produced during catarrhal affections, is confirmed by Hetterschig[1] and other observers; the secretion of mucus at the commencement of a catarrh is, however, more abundant than that which is produced by the irritation of existing tubercles.

The quantity of expectoration increases with the more extended deposition of tubercle, until softening commences; the tubercular matter is then expectorated, and, in consequence of the inflammation that occurs, pus is secreted by the walls of the cavity thus produced, and in this manner gets mixed with the sputa.

The purulent expectoration of persons with tubercular phthisis is easily distinguished by the experienced practitioner from healthy sputa,[2] and with tolerable certainty from diseased mucus, nor can there be any doubt regarding its nature while tubercular matter is being discharged from a vomica, but the transition from diseased into healthy purulent mucus is so slight and imperceptible, that it is hardly possible to detect the first traces of pus that are mingled with the mucus; for although, as I shall presently show, their general physical and chemical relations are perfectly sufficient to distinguish pure pus from pure mucus, we have no means of determining with certainty the presence of a little pus in mucus, or the presence of a little mucus in pus.

Purulent mucus from the lungs contains much less mucin than normal or diseased mucus,[3] and consequently the mucous clots have not the toughness, lubricity, and consistence observed in mucus, unmixed with pus: in fact they have a decided tendency to dissolve. Purulent mucus sinks more quickly in water than the normal secretion, partly in conse-

[1] De Inflammatione ejusque exitu diverso. Trajecti a. R. 1841, p. 176.

[2] [Dr. Wright's papers on Expectoration (recently published in the Medical Times) may be consulted with advantage.]

[3] [This is perfectly consistent with the observation of Eichholtz, that the pyin (or mucin) varies inversely with the pus-corpuscles.]

quence of the fewer air-bubbles that are inclosed, (on account of slighter tenacity of the fluid medium of communication, and the comparative facility with which they escape,) and partly in consequence of the greater amount of albumen in the fluid, and its higher specific gravity. If the secretion is composed of nearly equal parts of mucus and pus, it sinks rapidly to the bottom, and forms small definite tough clots: the masses may easily be broken up by means of a glass rod, and can often be separated by mere shaking: they have not so uniform an appearance as the healthy or morbid clots of mucus which float on water, but to the naked eye they appear finely granulated or gritty, since, in consequence of the deficiency of the connecting medium—the mucin, the cells of the secretion are not so closely associated.

When there is only a small amount of pus in the globular sputa during phthisis, it separates from the mucus on being placed in water; the pus at once sinks, and while the mucus is still floating on the surface we may observe long dependent viscid fibres, at the extremities of which white or yellowish granular particles of pus may be noticed.

Phthisical sputa deposit a whitish granular sediment at the bottom of the vessel, while masses of mucus are still floating on the surface of the water. A microscopic examination of the sediment shows that it consists of cells, which closely resemble mucus-cells, especially when they have been in the water for any time: since, however, the cells of purulent sputa come in contact with the water more readily in consequence of the smaller quantity of the connecting medium, mucin, they swell and become larger than the mucus-corpuscles, after they have been for only a short time in water: the capsules become transparent and vesicular, the granular appearance vanishes, and one, two, three, or even more nuclei with internal nucleoli, become visible: the capsules of many of the cells burst, and the nuclei swim about in a state of freedom, in the same manner as we observe in mucus that has been long under water. A microscopic representation of these pus-corpuscles is given in fig. 17. The water in which purulent mucus has been placed differs materially from that in which normal or diseased mucus has been swimming. It is either nearly clear and colourless, or else of a pale yellow tint, is viscid, and is slightly clouded

by acetic acid, but is rendered white and opaque by the addition of nitric acid: the action of heat likewise renders it turbid, and coagulates a considerable quantity of albumen, which separates in the form of flocculi.

Infusion of galls and basic acetate of lead cause dense precipitates; in fact, the addition of the former sometimes completely thickens the fluid.

The quantity of albumen is therefore much larger than in simply diseased mucus.

Pus.

Violent irritation of the mucous membrane may produce suppuration and cause a secretion of pus in place of the ordinary mucous secretion; thus it appears that the formation of pus is dependent on the very same process which, when acting with less intensity, first increases the secretion of mucus, and subsequently renders it abnormal. Pus, however, also forms in other and distinct parts of the body, after pre-existing congestion and inflammation, as for instance in cellular tissue, skin, muscular tissue, &c., and appears to differ both in its physical and chemical characters in accordance with the seat of its formation and the length of time that it has remained in the organism.

Genuine pus usually occurs as a rather thick fluid, viscid, but capable of separating in drops, somewhat like cream, of a whitish-yellow, yellow, or greenish-yellow colour, and of a faint but not disagreeable animal odour. It may be slightly acid, slightly alkaline, or neutral; when mixed with water it sinks rapidly to the bottom, but on stirring, it forms an emulsive fluid, from which a sediment of pus-corpuscles is soon again deposited.

When examined under the microscope, pus appears (like mucus) to consist of a clear fluid in which small, round, and occasionally oval corpuscles are swimming, the quantity of which seems to be in a direct ratio with the thickness of the pus. Pus- and mucus-corpuscles so closely resemble each other, that no distinctive mark, founded either on their form or on their chemical relations, has hitherto been discovered. The size of the corpuscles is nearly the same; in tough pus they are some-

what smaller, and in thin watery pus, rather larger than the mucus-corpuscles: oval corpuscles, which may be often seen in mucus, and are probably dependent on the viscidity of the secretion, are rarely found in pus.

In fresh pus the corpuscles are white, opaque, and apparently granular; when treated with water they become rather larger, lose, in some degree, their granular appearance, and soon give indication of an internal nucleus. With acetic acid they behave exactly in the same manner as mucus-corpuscles; the capsule becomes transparent and perfectly clear, and the nuclei become visible. The minuteness of the nuclei depends on the number that occur in the pus-corpuscle; we seldom find more than five, usually two or three. With the aid of a good light we may observe that many of these nuclear-cells possess a capsule and nucleolus. Pus-corpuscles dissolve rapidly in free potash, and more slowly in free ammonia. Other reagents produce the same effects as on mucus-corpuscles.

A very small quantity of dissolved alkali, such, for instance, as occurs in the blood, seems to exert a rapid influence on the form of the pus-corpuscle; for I have seen, in the blood of persons who have died from phlebitis, a large quantity of pus-corpuscles, (some isolated, and others swimming in heaps,) which were very pale, larger than usual, and of an irregular and tuberculated outline.

The liquor puris, or fluid in which the corpuscles are swimming, is transparent, and usually of a pale yellow colour; it contains so large an amount of albumen in solution, that, on the application of heat, it becomes perfectly white, and deposits innumerable flocculi of coagulated albumen. The large amount of albumen associated, moreover, with no trifling quantity of fat, distinguishes the liquid portion of pus from the tough and consistent fluid of mucus, and indicates the affinity between the liquor puris and lymph. The fat is partly combined with alkalies, and free fat-vesicles cannot always be detected. The largest portion of the fat is apparently contained in the pus-corpuscles; and, (as I have already observed when speaking of mucus,) the nuclei, if not composed altogether of fat, in all probability contain a very considerable proportion of that constituent; for, after the addition of acetic acid, I have frequently observed a greater or less number of fat-vesicles in

pus which previously exhibited no traces of them. The fatty matter of pus contains cholesterin, and, according to the observations of Güterbock, develops ammonia while burning; hence the presenee of a nitrogenous fat may be assumed. The liquor, puris is usually rendered turbid by acetic acid; the effect may vary from an almost imperceptible cloudiness to a decided precipitate; if the pus has an acid reaction, this test produces no change. There can be no doubt that the substances which are precipitated in this manner from the liquid parts of pus and mucus are analogous, and that the deposit which occurs in the liquor puris, after the addition of acetic acid, is either actual mucin held in solution by an alkali, or a substance scarcely differing from it,—pyin.[1]

The fluid portion of pus, like that of mucus, contains extractive matters and salts; the former occur in larger quantity in pus than in normal mucus. According to Güterbock,[2] the salts consist of chlorides, carbonates (arising from the decomposition of lactates), sulphates, and phosphates; the two latter doubtless arise in part from the oxidation of phosphorus and sulphur during the incineration of the albumen. The bases are potash, soda, lime, magnesia, and traces of iron. According to Martius,[3] the pus-corpuscles contain a little phosphate of lime and silica; others have placed the ammonia-salts amongst the constituents of normal pus.

The liquor puris is strongly precipitated by the mineral acids, metallic salts, and tannic acid, in consequence of its containing albumen, mucin, and extractive matter: after the addition of a little dilute hydrochloric or acetic acid, it is also precipitated by ferrocyanide of potassium. Small quantities of tubercle occur in the purulent sputa of phthisical patients, in the form of little, white, yellow, or brownish-yellow, irregular, and moderately soft masses, varying in dimensions from the size of a grain of sand to that of a small hemp-seed; they are usually inclosed in mucus, and sink rapidly in water. I have never observed many of these masses in the sputa; on the contrary, their occurrence was only very rarely noticed, considering the great number of phthisical patients in the Berlin hospital. The

[1] See note, page 74.
[2] De pure et granulatione, p. 18.
[3] Annalen der Pharmacie, vol. 24.

irregular fragments of tubercle appear to the eye to be of a caseous nature; but, after being moistened with water, submitted to pressure between two pieces of flat glass, and placed under the microscope, they seem to be composed of an amorphous, finely granular, opaque, yellow matter, in which there are a varying number of fat-vesicles and some minute ramifying tubuli or fibrils, as in fig. 18. We sometimes meet with peculiar forms in tubercle, which, doubtless, belong to the tissue or vessels of the lung; they have likewise been observed by Gruby, and I have represented several of them in fig. 19.

Gruby has observed peculiar corpuscles in tubercle which I have hitherto sought for in vain, both in tubercular lungs and in expectoration, and which he regards as characteristic of that morbid deposit. He describes them as lenticular, round, or oval, whitish-yellow corpuscles, with concentric rings, their lamellæ being arranged in the same manner as those of an onion, and their size being from two to ten times as large as a pus-corpuscle; they are frequently jagged at the edges, dissolve easily in caustic potash, and become distended in nitric acid and a solution of nitrate of silver.

It appears from the preceding observations that pus consists of two distinct portions; namely, of a fluid, the liquor puris; and of corpuscles swimming in this fluid and insoluble in it. The corpuscles are surrounded by a capsule, which becomes tumid in water, is soluble in free potash and is reduced by ammonia to a thick viscid jelly, dissolves on prolonged gentle digestion, and is doubtless composed of mucin. Of the nature of the contents of the corpuscles lying between the nucleus and the capsule we know nothing; the nucleus probably consists of albuminous matter and fat. The liquor puris contains albumen, fat, pyin or dissolved mucin, extractive matter, and salts. For the quantitative analysis of these substances I adopted the same method as in the analysis of mucus. (See page 75.)

Güterbock's quantitative analysis of pus was made in the following manner: Pus was boiled with anhydrous alcohol, and filtered while still hot; on cooling, the fat separated. The clear alcoholic solution was evaporated, and the residue treated with water, which dissolved the extractive matter and some free acid,

but left undissolved the small portion of fat that had escaped removal by the alcohol. The portion insoluble in boiling anhydrous alcohol was freed from the spirit by gentle evaporation, and treated with water which took up pyin, and some albumen probably combined with soda. The insoluble portion consisted of coagulated albumen and pus-corpuscles; the salts were determined by the incineration of a separate quantity of pus.

Normal pus has been analysed by Güterbock, Valentin,[1] G. Bird,[2] Wood,[3] [Von Bibra,[4] and Wright.[5]] The discrepancies observable in their results are probably due in a great measure to the different modes of analysis which they adopted. The pus analysed by Güterbock was taken from a mammary abscess. That which was analysed by Valentin came from a large abscess in a man's thigh; it was of a yellow colour, neutral, of a balsamic odour, and had a specific gravity of 1027. Wood analysed pus from the hand of a young man, and from abscesses in the cheek and breast of a woman. The analysis of the mixture is given below. The pus analysed by Golding Bird was taken from a psoas-abscess, and had a specific gravity of 1040·9.

Güterbock.

Water	861·0
Solid constituents	139·0
Fat, soluble only in hot alcohol	16·0
Fat and extractive matter, soluble in cold alcohol	43·0
Albumen, pyin, and pus-corpuscles	74·0
Loss	6·0

Valentin.

Water	883·78
Solid constituents	116·22
Cholesterin	11·86
Oleate of soda, olein, and chloride of potassium	10·02
Stearin	6·85
Coagulated albumen and fibrin	79·78
Fluid albumen and chloride of sodium	19·34

[1] Valentin's Repertorium, 1838, p. 307.

[2] Ancell's Course of Lectures on the Physiology and Pathology of the Blood, and the other animal fluids. The Lancet, 1839-1840, p. 745.

[3] De puris naturâ atque formatione disq. phys. Berlin, 1837, p. 10.

[4] Unters. über einige verschiedene Eiterarten. Berol. 1842.

[5] Medical Times, Jan. 11, 1845.

Golding Bird.

Water	898·00
Solid constituents	102·00
Fat	5·00
Water-extract, with alkaline lactates . .	8·00
Albumen	75·75
Chlorides of sodium and potassium, with carbonates .	5·75
Phosphates of lime and iron . . .	7·50

Wood.

Water	857·15
Solid constituents	142·85
Cholesterin	1·57
Oleate of soda	10·91
Extractive matter, with chloride of sodium and other salts	8·34
Albumen	19·09
Animal matter, with the properties of ptyalin and glutin	16·57
Fibrous matter, with phosphate of lime, peroxide of iron, and sulphur	86·37

The salts amounted, according to Güterbock, to 5·7% of the solid residue, namely, to 5 soluble in water, (consisting, for the most part, of chloride of sodium with small quantities of phosphate, sulphate, and carbonate of soda, chloride of potassium, and chloride of calcium,) and 0·7 soluble only in nitric acid, and composed of the phosphates of lime and magnesia, carbonate of lime, and a trace of peroxide of iron.

Valentin estimated the salts at 5·32% of the solid residue, of which 4·7 were soluble in water, (chloride of sodium with traces of the sulphates of potash, soda, and lime, and carbonates of potash and soda,) and 0·62 insoluble in water, (phosphate, sulphate, and carbonate of lime.)

[A large number of analyses of pus and purulent sputa have been made by Von Bibra. We select the three following :

	Pus from an abscess in the cheek.	Ditto in the chest.	Ditto in the neck.
Water . .	769	852	907
Albumen and pus-corpuscles	160	91	63
Fat . .	24	33	9
Extractive matter .	19	29	20

Several analyses of pus have been made by Dr. Wright. The three following analyses will serve as specimens :

	Pus from a vomica.	Pus from a psoas abscess.	Pus from a mammary abscess.
Water	894·4	885·2	879·4
Fatty matter	17·5	28·8	26·5
Cholesterin	5·4		
Mucus	11·2	6·1	
Albumen	68·5	63·7	83·6
Lactates, carbonates, sulphates, and phosphates of soda, potash, and lime	9·7	13·5	8·9
Iron	a trace		
Loss	3·3	2·7	1·6

Nasse[1] has published two analyses, one of serum of pus, and the other of serum of blood, with the view of comparison. The following are his results:

	Serum of pus.	Serum of blood.
Water	890·00	906·5
Solid residue	110·00	93·5
Organic constituents	92·58	85·7
Chloride of sodium	12·60	4·6
Carbonate of soda	2·22	1·4
Phosphate of soda	0·32	0·9
Sulphate of soda	0·18	0·2
Phosphate of lime	1·20	0·7
Carbonate of lime	0·90	

I made an analysis of pus which was discharged with the urine by a servant-girl with phthisis vesicæ: it was rather tough, of a reddish colour, in consequence of a little blood that was mixed with it, and quickly sunk to the bottom of the vessel, after the urine had been stirred. Before examination, it was washed with water and evaporated to dryness on the water-bath. There were contained in 100 parts:

	Analysis 90.
Fat containing cholesterin	5·20
Albumen, with phosphate of lime	40·20
Pyin, casein or globulin, and some extractive matter	17·00
Hæmatin, urea, alcohol-extract, and lactate of soda	10·60
Spirit-extract, with chloride of sodium, lactates, and phosphates	1·30
Water-extract, with phosphates and sulphates	13·80

Pus secreted by the synovial membrane of the knee-joint is composed, according to Wood,[2] of water, 888·1; cholesterin, 4·0; oleate of soda with soda, and potash-salts, 22·4; animal matter and chloride of sodium, 30·2; a substance resembling glutin,

[1] Simon's Beiträge, p. 338. [2] Op. cit. p. 21.

15·2; albumen, 40·1. Martius[1] analysed a purulent fluid obtained from a patient with empyema, from whom 153 ounces of matter were evacuated. It was tolerably thick, of a dirty greenish-gray colour, devoid of odour, and had a slightly acid reaction: when heated it swelled very much; it sunk to the bottom in water, but on agitation the two fluids mixed. On boiling it, some floccules separated themselves, but no coagulation took place; the fluid, after filtration, was of the colour of sherry, and had a specific gravity of 1111·5.[2] The principal constituents were water, fat, albumen, extractive matter, glutin, potash, soda, magnesia, lime, ammonia, phosphoric, hydrochloric, and lactic acids. Koch[3] analysed pus with very similar results: it is not stated from whence the pus was obtained; it consisted of water, albumen, extractive matter, mucus, and pus-corpuscles. In addition to the salts found by Martius, Koch detected carbonates and sulphates, resulting from the action of heat on lactic acid and sulphur during incineration.

John[4] describes pus from the ovary of a consumptive woman, as a greenish fluid, of the consistence of a liniment, and with a peculiar odour; it contained albumen, a substance resembling that substance, resin, gelatinous matter, and the ordinary salts, together with carbonate of ammonia.

Chevallier[5] found in pus from a syphilitic bubo in the axilla, ten days after its formation, albumen, gluten, chlorides of potassium, sodium, and ammonium, with some sulphates; it was viscid, of a blood-red colour, of a sickly odour, neutral, and coagulated on heating. The fluid from an abscess, in a case of spina bifida, contained, according to Bostock, water, 978; chloride of sodium, 10; albumen, 5; mucus, 5; gelatin, 2; and a trace of lime. The fluid which Gruby obtained from the pustules in smallpox, twenty or thirty hours after the commencement of the eruption, had an alkaline reaction; it contained some white, nearly transparent molecules, and round caudate infusoria. On the third day pus-corpuscles were observable, and subsequently became more numerous.

[1] Annal. der Pharm. 24. p. 79.
[2] This must be an error of observation or a misprint.
[3] Diss. inaug. Berol. 1825.
[4] Chemische Untersuchungen, vol. 2. 1812, p. 120.
[5] Gmelin's Chemie, vol. 2, p. 1395.

On the fifth, sixth, eighth, and ninth days after the commencement of the eruption the pustules contained a thick yellow fluid, which had a slightly alkaline reaction, and contained numerous yellow pus-corpuscles, the capsules of which readily burst.

Tremoliere describes the contents of a well-conditioned pustule as yellow, turbid, and with an oily appearance. The smell and taste of this fluid were unpleasant, its specific gravity was 1031, and it consisted, according to his statement, of fibrin, mucus, chloride of sodium, sulphate of potash, and phosphate of lime. Gruby found that the fluid in the pustule on the seventh day was transparent; it contained white, nearly spherical vesicles, which appeared wrinkled on one side.

Vogel has made some important observations regarding the modifying influence of tissue, constitution, &c., on the nature of pus.

Pus from the cellular tissue is usually the purest, pus from mucous or serous surfaces being too thin and fluid, and containing in one case an admixture of mucus, in the other of serosity. Pus from the liver is pultaceous, thick, and of a brownish red colour. On allowing it to stand for some time, a dense, thick, and reddish matter separates from the white pus. Pus from the kidneys is usually rather fluid, of a whitish-yellow colour, and saltish. Pus from the urinary bladder may be either fluid or tough, and varies in colour from a yellow to a dirty brown-red tint; it frequently also has an ammoniacal odour. Pus from the bones is blackish, or white with black specks; it has an odour and taste of phosphorus. Syphilitic pus is of a yellow or yellowish-green colour; it possesses a nauseous smell, and a sweet but sickly taste. Scrofulous pus is caseous, very fluid, grumous, and sometimes resembles coagulated milk; according to Gendrin, it contains more soda and chloride of sodium than ordinary pus; according to Preuss, it contains casein, like tubercular matter. Rheumatic and arthritic pus are very similar; for the most part very fluid, irritative, and corrosive. I have examined the dried residue of the liquor puris of an arthritic person; it was of a grayish-yellow colour, contained no membranous shreds, could be easily pulverised, and exhibited no appearance of crystals when examined under the microscope. On heating it with nitric acid, I

obtained, after the evaporation of the acid, and more strikingly on the addition of ammonia, a brilliant purple colour, indicating the presence of uric acid beyond a doubt. On triturating this substance with water I obtained a pulpy mass, which, when examined under the microscope, was found to contain numerous epithelium-cells and pus-corpuscles, but no crystals of uric acid. Alcohol extracted 5·4% of fat, consisting chiefly of margaric and oleic acids, with a little cholesterin; boiling water took up 52·6%, of which a little fat, extractive matters, with hydrochlorate of ammonia and lactate of soda, were soluble in anhydrous alcohol; and chloride of sodium, extractive matter, and albuminate of soda in spirit. The remainder was washed with cold water, (which extracted very little,) and was then dissolved in a faintly alkaline solution. On the addition of hydrochloric acid to this alkaline solution, crystals of uric acid were deposited, and some albumen thrown down from the albuminate of soda: the acid solution then contained hydrochlorate of ammonia and chloride of sodium. The portion insoluble in water yielded on incineration 5% of ash, consisting of earthy phosphates, with a little peroxide of iron and carbonate of soda; the dried residue of the liquor puris yielded, however, 10% of ash, composed of carbonate of soda, a little phosphate of soda, carbonate and phosphate of lime, a little chloride of sodium, and traces of peroxide of iron. It contained in 100 parts:

	Analysis 91.
Portion insoluble in water	47·4
Fat	5·4
Alcohol-extract, with hydrochlorate of ammonia and lactate of soda	4·9
Spirit-extract, with chloride of sodium and albuminate of soda	17·5
Uric acid and albumen, combined with ammonia and soda	17·2

The amount of the individual salts was not determined.

I have received, through the kindness of Dr. Piutti, of Elgersburg, two small flasks filled with a white fluid discharged from an abscess on the foot of a gouty patient, who had been trying the water-cure. On standing, the fluid threw down a copious white sediment, the supernatant liquid portion having a reddish tint. When shaken, innumerable crystals might be observed with the naked eye, which, under the microscope, exhibited an acicular form; a few pus-corpuscles were also present.

The crystals, after being carefully washed, so as to remove all extraneous matter, formed, when dry, a white powder, and when incinerated on platinum foil, left a white fused ash, consisting of carbonate of soda. The white crystalline mass, when warmed with nitric acid, yielded the deep purple tint indicative of uric acid. On digesting a portion with dilute hydrochloric acid, a large number of rhombic tablets of uric acid appeared on cooling. The hydrochloric acid solution yielded, on gentle evaporation, crystals of chloride of sodium. Hence the white acicular crystals consisted of urate of soda. The red supernatant fluid contained a few corpuscles, a large quantity of albumen, and some hæmatoglobulin.

Scorbutic pus is thin, ichor-like, of a bad odour, often mixed with blood, and soon becomes putrid. Cancerous pus possesses a very peculiarly fetid odour, and appears very frequently to contain sulphuretted hydrogen and ammonia.

Pus sometimes contains infusoria; thus R. Wagner[1] has observed minute ciliated animalcules, in some slight degree resembling pus-corpuscles, in pus taken from cancer of the lip; they appeared to be the *colpoda cucullus*. Valentin has also observed infusoria in the purulent fluid of carcinoma. Donne[2] has observed the *vibrio lineola* in the pus from chancres and gonorrhœa: he found other forms of infusoria in the pus from syphilitic vaginitis; they were twice the size of the blood-corpuscles, with a round or elliptic body, considerably prolonged anteriorly; he proposes for this animalcule the name of *tricomonas vaginalis*.

Ichor.

When pus begins to undergo decay, or is secreted from malignant or carcinomatous growths, or when mortification comes on in consequence of the depressed state of the vital powers, it becomes thin and discoloured, (being often of a brown or reddish tint,) and emits a fetid odour: it is then termed ichor. Ichor frequently contains no pus-corpuscles, or only a very few, and those partially broken: it is of a blood-red colour, but does not always contain blood-corpuscles, the red colour being apparently due to their solution in the putrid and decomposed fluid. From

[1] Valentin's Repertorium, p. 119.

[2] Recherches microsc. sur la nat. du Mucus, etc. Paris, 1837.

the odour we may infer the presence of hydrosulphate of ammonia. Vogel examined some ichorous pus from a sore in the foot of a rheumatic patient; he found perfectly normal pus-corpuscles in it, and it only differed from normal pus in its greater fluidity.

Pus of animals.

I have analysed pus from a lymphatic gland in a horse. There were contained in 1000 parts:

	Analysis 92.
Water	976·00
Solid constituents	24·00
Fat, containing cholesterin	1·68
Water-extract and caseous matter	1·26
Spirit-extract, with lactates, and chloride of sodium	2·94
Albumen, cells, phosphate and sulphate of lime, and traces of iron	17·64

Göbel[1] has analysed pus from the uterus of a mare; it was a thick fluid, of a whitish-yellow colour, opaque, of specific gravity 1079, and had a faint animal odour: it was neutral, and coagulated on the application of heat. It contained, water, 913·3; albumen, 7·2; gelatinous non-coagulable animal matter, 9·4; chloride of sodium, lactate and sulphate of potash, phosphates of lime and magnesia, protoxide of iron, and silica, 5·3. Dumas analysed pus from the frontal sinus of a mule: it reddened litmus paper, formed an emulsion with cold water, and when heated to 158°, yielded a granular coagulum. It contained 17·9% of solid constituents, of which 16·5 were albumen; the remainder consisted of extractive matter, free lactic acid, phosphates and sulphates.

On the formation of mucus and pus on mucous membranes, and on the detection of pus in mucus.

It seems to be now almost generally admitted that the distinctions between pus and mucus are to be sought for, not in the morphological character or chemical relations of their respective corpuscles, but rather in the chemical peculiarities of the fluid portions of these secretions.

It has been already shown that the fluid of mucus contains a large quantity of dissolved mucin, while no albumen, or, at the most, a mere trace, is present: on the other hand, the fluid of

[1] Schweigger's Journal, vol. 34, p. 407.

pus is rich in albumen, and contains only a very small quantity of dissolved mucin. Hence, if it were proved that normal mucus never contains albumen, we might conclude that all mucus which gave indications of the presence of that substance was purulent. We should then also arrive at the conclusion that most persons, on the slightest irritation of the mucous membrane, secrete purulent mucus. In this manner we should have to agree with Vogel that normal mucus contains only epithelium, and that any secretion of mucus-corpuscles indicates an admixture of pus.

To the physician the detection of traces of pus in mucus is a point of little importance; it is of much more consequence to be able to decide from the sputa whether suppuration of the parenchyma of the lungs or of other tissues has actually commenced. The point is one of very great difficulty, in consequence, as has been previously observed, of the imperceptible changes that mucus undergoes in its transition from the normal secretion into pus.

My own observations, as well as those of others, lead me to concur in the view that Henle[1] has developed in his essay on the Secretion of Pus and Mucus, in which he distinctly and ingeniously points out the analogous phenomena between mucous membranes and the external skin. The mucous membranes are covered with several layers of epithelium, and in the ordinary course of secretion, the more recent and inferior layer of cells projects against the superior and older cells which constitute the existing epithelium. The inferior cells themselves gradually become epithelium, and, in their turn, are thrust out and supplanted by still deeper cells. As the fluid portion of the mucus is secreted at the same time, it evidently cannot be regarded as the cytoblastema of these cells, but must be looked upon as effete, and no longer essential to the formation of mucus-corpuscles; the albumen for their nutrition having been extracted from it during the progress of their development towards actual epithelium, and only mucin (the product of their metamorphosis) left in its stead.

As the secretion is increased by irritation of the mucous membrane, it follows either that such epithelium as is thrown off in the normal state is then not formed at all, or else that it is

[1] Hufeland's Journal, May 1836.

only secreted imperfectly, and consequently we meet with cells in every state of development under these circumstances. These changes in the epithelium lead to corresponding variations in the fluid portion of the mucus, for if a normal stratum of epithelium is no longer formed, that is to say, if the deeper layers throw off the superior cells before they have arrived at maturity, the changes impressed on the fluid must be different from those which it would undergo during the ordinary secretion of healthy mucus. It is impossible that all the nutritious matter of this fluid can be consumed by these immature cells, and we consequently find in it, under these circumstances, a greater or less quantity of albumen and fat, two substances which universally yield a cytoblastema for the higher development of cells.

If an increased secretion of mucus takes place on a mucous membrane which possesses only a single layer of epithelium, (either the cylinder or the ciliated variety,) the mucus-corpuscles appear immediately after the epithelium has scaled off. The transition of the mucus-corpuscles into epithelium-cells is not observed so well in this instance, as when there is a profuse secretion from a surface possessing several layers. These transitions and various stages of development lead us to the conclusion that the mucus-corpuscles represent the first stage of formation of the epithelium-cells, into which they would ultimately have been converted if they had not been thrown off too early, and, further, that the different forms of epithelium-cells are in their primary state identical with one another.

The same elements are likewise recognised, according to Henle, in other tissues, in the ganglia of nerves, in the brain, in the contents of the Graafian vesicle around the ovum, in the parenchyma of the liver, and in the blood-formative glands, (the spleen, thymus, and thyroid.) These cells occur also in the blood, where I have termed them chyle-corpuscles; they probably represent the blood-corpuscle in a preparatory stage of development.

If we suppose the secretion of mucus to be still further increased, the mucous membrane will produce only these primary cells, which cannot be distinguished from pus-cells, with which, in fact, they are identical. Whether the secreted fluid is to be regarded as pus, mucus, or purulent mucus, depends on the quality of the liquid that is secreted with the cells. If it con-

tains much mucin, the fluid must be regarded as mucus; if there is no mucin in it, or only a small quantity, but on the other hand much fat and albumen, it must be regarded as pus; while if all three are contained in the fluid, it must be regarded as purulent mucus. In a very diseased state of the mucous membrane the fluid may even contain fibrin, and thus resemble plastic lymph. Henle[1] has observed this in one instance. We may consequently observe the various stages of transition from plastic lymph to the normal fluid of mucus (containing mucin, but no albumen), in the same manner as we can trace the epithelium-cells gradually downwards till they assume the form of primary cells.

The following conclusions are all that we are entitled to deduce from the previous observations:

(1.) Pure mucus floats on water for a considerable time if air-bubbles are entangled in it; pure pus sinks rapidly to the bottom; purulent mucus swims if it contain air-bubbles, but allows the pus to deposit itself; the deposit frequently takes place in the form of pendent fibres. If pure mucus contain no air-bubbles it sinks.

(2.) Pure mucus, lying in water, appears as a homogeneous, streaked, vesicular, viscid, and tenacious mass, of a white or whitish-yellow colour, and yielding readily to pressure. Pure pus forms a stratum at the bottom of water, of a white or greenish-yellow colour, and sometimes tinged with blood; by agitation it is diffused through the water, and in a short time again sinks to the bottom. Purulent mucus forms streaked, vesicular, often discoloured masses, or mucous sediments; they are easily diffused through water, and have a granular, non-homogeneous appearance.

(3.) Pure mucus imparts no albumen or mucin to water; mucus which is mixed with much saliva does, however, render water a little albuminous; pure pus communicates a large amount of albumen to water, and purulent mucus imparts a quantity of albumen proportionate to the amount of pus.

None of what have been termed the "pus tests" are calculated, in my opinion, to detect minute quantities of pus in mucus, and no test is requisite to distinguish pure mucus from pure pus, or to recognise a large quantity of pus in mucus.

[1] Hufeland's Journal, 1836, p. 21.

CHAPTER VI.

SECRETION OF THE EXTERNAL SKIN.

Sweat. (*Sudor.*)

THE sudoriparous glands continuously secrete a very considerable amount of watery fluid, which, in consequence of the extent of surface over which these glands are distributed, usually passes off directly in the shape of vapour, leaving behind, however, on the skin, its various solid constituents, mixed with the secretion of the sebaceous glands. It is only under the influence of active exercise, high external temperature, or certain forms of disease, that the secretion is elaborated in such quantity as to stand in drops on the skin, instead of being carried off as insensible vapour; it is then termed *sweat.*

Attempts have been made by Sanctorius, Dodart and Reil, and more recently by Lavoisier and Seguin, to determine the quantity of fluid which escapes from the skin within a certain time, in the form of vapour. Seguin found that, on an average, 18 grains of fluid were discharged in a minute by the skin and lungs; the former exhaling 11 and the latter 7 grains. The minimum exhalation from both sources amounted to 11 grains; the maximum, in a state of rest, to 32 grains in a minute. From these data the maximum of matter lost by the body through the skin and lungs in 24 hours, would amount to 5 pounds, and the minimum to 1 pound, 11 ounces, and 4 drachms. Taking the average of 11 grains in the minute, the whole quantity would amount to 29 ounces of fluid.

The amount of solid constituents carried off with the fluid, is comparatively very small, and does not exceed 7 or 8 scruples in the 24 hours: all the rest is mere water, with some carbonic acid, and perhaps some nitrogen.

The solid constituents of the sweat consist of a mixture of salts and extractive matters, of which the latter preponderate; the principal ingredient of the salts is chloride of sodium.

I have on several occasions collected and analysed the sweat of persons in the vapour-bath; it is, however, always mixed with more or less water condensed on the body from the vapour of the bath. The sweat collected in this manner from the arms and face was a turbid, rather dirty-looking fluid, which, after standing for some time, deposited gray floccules, recognizable under the microscope as epithelium-scales, for the most part broken and in fragments. The filtered sweat had in one instance a specific gravity of 1003, in another of 1004; it was slightly acid, which appears to be the ordinary reaction of normal sweat; in the course of 24 hours it became neutral, and on holding over it a rod moistened with hydrochloric acid, a slight cloud was observed.

On evaporation of my own sweat, as well as that of another healthy man, the peculiar smell of the axilla was observed, and an odour of ammonia developed; the presence of this substance was also indicated by the test to which we have just referred. On evaporation to dryness, the odour of extractive matter became perceptible. On triturating a portion of the residue with free potash, ammonia was developed; on the addition of sulphuric acid to another part, sulphurous acid was first given off, and afterwards a marked odour of acetic acid. In one instance the odour of butyric acid was so clearly associated with that of acetic acid, as to leave no doubt of its presence.

On boiling the dried residue of sweat with ether, a small quantity of fat is taken up, which may be isolated by evaporating the ether, and possesses the peculiar odour of sweat. Alcohol, on being then added to the residue, becomes of a pale yellow colour, and is rather strongly precipitated by tannic acid and acetate of lead,—indications of the presence of alcohol-extract. On evaporation of the alcohol, chloride of sodium crystallizes in cubes, and in addition to these cubes, which constitute the greater part of the salts, and many of which have octohedral surfaces, there are also long prisms, plates, and fern-like crystalline clusters of hydrochlorate of ammonia; the latter, especially, is very abundant in sweat that has stood for some time. On treating a portion of the residue of the salts with sulphuric acid, there is extricated in the first place some hydrochloric acid in a state of vapour, and subsequently a decided odour of acetic acid.

If a portion of the residue is incinerated, the ash effervesces on the addition of hydrochloric acid. On dissolving out the chlorides with alcohol, and adding bichloride of platinum, we obtain a slight yellow precipitate. The residue is soluble in water, with the exception of some gray flocculi, and on the addition of tannic acid this aqueous solution yields a precipitate, which shows that the sweat contains water-extract. The solution also contains a small quantity of lime, but hardly a trace of phosphoric acid, and only once, in several trials, was there a faint indication of sulphuric acid. When the whole residue of the sweat was incinerated, the amount of phosphate of lime was much larger, and a considerable quantity of sulphuric acid, as well as traces of peroxide of iron, were always perceptible.

It is true that these are superficial and merely qualitative investigations; they are, however, sufficient to establish the existence, in normal sweat, of

1. Substances soluble in ether: traces of fat, sometimes including butyric acid.

2. Substances soluble in alcohol: alcohol-extract, free lactic or acetic acid, chloride of sodium, lactates and acetates of potash and soda, lactate or hydrochlorate of ammonia.

3. Substances soluble in water: water-extract, phosphate of lime, and occasionally an alkaline sulphate.

4. Substances insoluble in water: desquamated epithelium, and (after the removal of the free lactic acid by alcohol) phosphate of lime, with a little peroxide of iron.

The results of the investigations of other chemists coincide generally with these conclusions of mine. Berzelius infers from his analyses of sweat that collected in drops on the forehead, that it contains in solution the same substances which occur in a dissolved condition in the acid fluid of muscular flesh, together with an excess of chloride of sodium. The most comprehensive analyses of sweat have been made by Anselmino.[1] He inclosed the naked arm in a glass cylinder, and collected the sweat that had exhaled during several experiments: in the course of five or six hours a table-spoonful had condensed. A portion was heated with sulphuric acid, evaporated, and

[1] Tiedemann's Zeitschrift, vol. 2, p. 321.

caustic potash added to the residue; by this means the presence of ammonia was established beyond a doubt. On digesting another portion with oxide of lead, and moistening the dried mass with sulphuric acid, vapours of acetic acid were developed. A third portion, which was treated with lime water, became turbid, in consequence of the presence of carbonic acid. For the purpose of determining the solid constituents, Anselmino made use of sweat that had been collected by clean sponges from the vapour-bath; it was turbid, and had a strong though by no means a constant odour. After the distillation of a portion of the filtered liquid in the steam-bath, acetate of ammonia was found in the fluid that had collected in the receiver. A very small amount of solid residue (from 0·5 to 1·25%) was left after evaporation of the sweat. Anselmino extracted the solid residue with alcohol of ·833, evaporated the alcoholic solution to dryness, and then, by means of anhydrous alcohol, extracted from the saline residue an acid, extract-like matter, similar to the alcohol-extract of flesh, and containing free acetic acid, acetate of potash, and animal matter precipitable by tannic acid. Berzelius conceives the free acid of this extract (like the free acid in extract of flesh,) to be lactic acid. Now I will not assert that the sweat always contains free acetic acid, but I certainly have observed cases in which the odour clearly showed that the free acid was principally the acetic; lactic acid may, however, still be always present. The occurrence of acetic acid in sweat is placed beyond a doubt by my experiments. The matters which are undissolved by anhydrous alcohol are principally chlorides of sodium and potassium, and spirit-extract; the latter is not precipitated by chlorine, protochloride of tin, or bichloride of mercury. In this investigation Anselmino seems to have overlooked, as Berzelius remarks, the hydrochlorate and lactate of ammonia. All that is insoluble in alcohol may be dissolved in lukewarm water, with the exception of a gray matter; this aqueous solution contains sulphates and an animal matter precipitable by tannic acid, and perchloride of tin, (water-extract.) The gray insoluble matter leaves on incineration a considerable amount of phosphate, together with a little carbonate of lime.

Anselmino has consequently arrived at results which entirely correspond with my own, excepting only that I could not in every

case detect the presence of sulphates in fresh sweat, although I always found them in the incinerated residue; from this circumstance I am led to infer that some of the constituents of sweat contain sulphur.

In 100 parts of the solid residue of sweat Anselmino found:

Substances insoluble in water and alcohol, chiefly salts of lime	2·0
Water-extract and sulphates	21·0
Spirit-extract, with chlorides of sodium and potassium	48·0
Alcohol-extract, acetic acid, and acetates (lactates)	29·0

These figures must be regarded merely as approximative. In 1000 parts of sweat there are contained, according to Anselmino:

Water	995·000	987·500
Epidermis and salts of lime	·100	·250
Water-extract and sulphates	1·050	2·625
Spirit-extract, chlorides of sodium and potassium	2·400	6·000
Alcohol-extract, acetates, lactates, and free acetic acid	1·450	3·625

From 100 parts of dried residue of sweat Anselmino obtained 22·9 of fixed salts, consisting of carbonates, sulphates, and phosphates of soda and (in small quantity) of potash, chloride of sodium, phosphate and carbonate of lime, and traces of peroxide of iron.

The peculiar odour of sweat from different parts of the body is dependent in a great measure on the secretion of the sebaceous glands in those parts: thus it is well known that the sweat from the feet of many persons has a very penetrating odour, that the sweat from the axilla gives off a peculiar ammoniacal smell, and that the sweat of the external organs of generation contains and smells faintly of butyric acid.

The gases which are given off by the skin are, according to Collard de Martigny,[1] carbonic acid and nitrogen; they are not exhaled in constant, but in varying proportions, and generally in the greatest quantity after meals and after violent exertion. Collard has observed that an excess of carbonic acid is exhaled after the use of vegetable food, and an excess of nitrogen after a nitrogenous diet. Since these gases are contained in a state

[1] Magendie's Journal, vol. 10, p. 162.

of solution in the blood, (see vol. I, p. 135,) it may readily be conceived that they will exhale at those points where the blood in its passage through the capillaries comes in the most intimate contact with the external atmosphere; at least it seems a simpler view to regard it as a mere physical process than as a disintegration of animal matter by the secreting organs. In fact, the cutaneous exhalation must be regarded, as Edwards has observed, in the light of a partly physical, partly organic process. The product of physical exhalation is pure water and gas; the product of organic exhalation contains animal constituents, which must be regarded as secretions of cells.

The amount of exhaled matter is liable to great variations: it is increased by a dry and light atmosphere; and is lessened by a moist, vapoury, dense, and calm atmosphere. During and immediately after meals the exhalation is at its minimum; it attains its maximum during the actual period of digestion. The cutaneous exhalation is in antagonism with the urinary secretion and the pulmonary exhalation, so that an excessive secretion of urine diminishes the action of the skin, and, conversely, the renal functions are less energetic when the skin exhales freely.

On Morbid Sweat.

Our knowledge of the chemistry of normal sweat is very imperfect; but our information respecting the changes which this secretion undergoes in disease is still more deficient. Our ignorance may be explained, and in some measure excused, by the extreme difficulty of obtaining, in a state of purity and unadulteration, a sufficient quantity of the secretion for the purpose of forming a successful chemical analysis.

Dr. Piutti, of Elgersburg, has had the kindness to present me with some sweat which he obtained from persons during the use of the water-cure, and also with a manuscript communication containing some analyses of sweat instituted by himself, which I shall at once proceed to enumerate.

The manner in which he conducted his analyses is not stated. We observe the absence of salts of lime in these analyses, and Piutti states that he could find no traces of phosphate or benzoate of lime, the former of which has indisputably been de-

tected by other chemists. Since the phosphate of lime doubtless pertains to the epidermis, we may conclude that Piutti removed all the desquamated cuticle before he commenced his analyses.[1] All mention of sulphuric acid, and of potash, is likewise omitted. I have already stated that I only once detected traces of sulphuric acid in fresh sweat, although I always found a considerable quantity of it in the incinerated ash. Piutti has made three analyses of the sweat collected from invalids. They gave the following results:

	1.	2.	3.
Water . . .	995·5	993·0	994·6
Chloride of sodium . .	3·0	4·0	3·3
Phosphate of ammonia . .	·5	·8	1·1
Acetate of ammonia . .	·5	·6	·5
Hydrosulphate of ammonia .	trace		trace
Extractive matters . .	·5	1·6	·5

The first analysis was made with the sweat of a man aged 36 years, who during twelve years had suffered from atonic gout, and had been trying the water-cure for ten weeks. The specific gravity of the sweat was 1003·5. The sweat in the second analysis was taken from a woman aged 54 years, who for six years had suffered from gout, and who had been under the water-cure for twelve weeks: its specific gravity was 1004. In the third case it was collected from a girl 22 years of age, suffering from paralysis of the lower extremities, but in other respects blooming and healthy. The animal matter in this case was of a greenish colour when isolated; it was soluble in ether, but not in alcohol. The specific gravity was 1003.

The sweat that was forwarded to me by Dr. Piutti, and which was inclosed in ounce-bottles with ground stoppers, was in a state of decomposition when I received it, and therefore was not in a proper condition for an accurate qualitative analysis. It smelt strongly of hydrosulphate of ammonia, especially a specimen collected from a man who had had psoriasis diffusa for seventeen years. The gray deposit which was found in every bottle consisted of desquamated epidermis. The sweat, to which I have just referred, had a penetrating odour of sul-

[1] Berzelius, however, is of opinion that a portion of phosphate of lime appertains to the sweat itself, and that it is held in solution by a free acid.

phuretted hydrogen, which continued during evaporation, and ultimately merged into a nauseous animal smell. Its specific gravity was comparatively high, being 1008; and it yielded 9·9 of solid constituents, which, after being exposed to the influence of a red heat, were found to consist of a large proportion of chloride of sodium, carbonate of soda, a little phosphate of lime, and a fair amount of sulphuric acid.

The statements which we possess from other sources, regarding the morbid changes of the sweat, are very loose and inconclusive; in fact we have no accurate observations on the subject.

1. *The quantity of the sweat is sometimes increased in an extraordinary degree.*

Thus critical sweats are usually very abundant, continuous, and watery, in intermittent fevers, in rheumatic affections, and in colliquative disorders.

2. *The quality of the sweat is changed.*

a. The sweat may be distinguished by a peculiar odour. The sweat of persons with the itch is said to have a mouldy odour, while that of syphilitic patients is said to smell sweet. The sweat of rheumatic and gouty persons has an acid smell, while in putrid fever and scurvy, it has a putrid odour; in jaundice it is said to resemble musk in its smell. In Stark's 'General Pathology,' (p. 1126,) we find it stated that the odour of the sweat in scrofula resembles that of sour beer, while in intermittent fever it smells like fresh-baked brown bread. The determination of odours is, however, very subjective, and (with a few exceptions) it is more than probable that different observers would detect different resemblances.

b. Some of the normal constituents may be abnormally increased.

1st. *The free acid of the sweat may be increased.* Lactic acid, which is the ordinary free acid, is usually increased in cases of rheumatism and gout; the sweat in these diseases has a strong acid reaction. When there is also an acid odour, acetic acid is present. Prout has found free acetic acid in the

sweat of a person suffering from hectic fever. After an attack of acute rheumatism, the joints of the feet remained swelled, for which potash-baths were ordered. These baths, in the course of three weeks, brought on an attack of eczema, extending as high as the knee. The sweat from the feet had then a decided odour of acetic acid, which became more strongly developed when they were sharply rubbed. Anselmino[1] found free acetic acid in the sweat of women during their confinement; and, according to Stark, the quantity of free lactic acid is increased in the sweat during scrofula, rachitis, and certain cutaneous eruptions.

2d. *The ammonia of the sweat may be increased.* Anselmino found a larger proportion of (free?) ammonia in the sweat after an attack of gout than in any other case. Berend[2] states that the sweat in putrid and typhus fever is ammoniacal; and in nervous diseases (?), according to Nauche,[3] it becomes alkaline. All sweat with a putrid odour probably contains free ammonia.

3d. *The salts may be increased.* Prout[4] observed that in the case of a man with dropsy the skin became covered with a white saline crust of chloride of sodium, after an abundant perspiration. Anselmino found in the sweat, after a severe attack of gout, more salts than usual. In cases of gouty and urinary concretions, the quantity of phosphate of lime appears to be increased.

c. Abnormal constituents may be present in the sweat.

1st. *Albumen* has been observed by Anselmino in a critical sweat, which broke out in large quantity one evening over the whole body in a case of febris rheumatica, with severe pains in the joints; on the following day it had disappeared. Stark asserts that albumen may be found in the sweat in gastric, putrid, and hectic diseases, and also on the approach of death, in consequence of the abnormal solution of the solid constituents. I failed in detecting any certain indications of albumen in sweat collected (by means of linen washed with distilled water) from the breast of a person in the colliquative stage of tubercular phthisis.

[1] Tiedemann's Zeitschrift, vol. 2, p. 223.
[2] Vorlesungen über Semiotik, p. 388.
[3] Stark, p. 1127.
[4] London Med. Gaz. vol. 15, Oct. 1834.

2d. *Blood or its constituents.* Voigtel[1] observed an instance of bloody sweat from under the arm of a young man; it appeared after any violent exertion. In scurvy, putrid fever, and typhus icterodes, bloody sweat has likewise been observed.

3d. *Uric acid* is stated to have been found in the sweat of arthritic persons (Stark). Wolff[2] found that the sweat which had hardened on the forehead into a solid white substance, (in a patient with stone in the bladder,) contained uric acid. Urate of soda is likewise stated to have been found in the sweat of persons suffering from gout or stone.

4th. *Bilin and biliphæin* have been found in the sweat of persons with jaundice, and sometimes in such large quantity as to colour the linen yellow, and to communicate a bitter taste to the perspiration. According to Berend, the sweat in febris putrida biliosa likewise contains bile-pigment.

5th. *Red colouring matter of the urine* (*uroerythrin*) was found by Landerer[3] in sweat from the axilla of a fever patient. A blue colouring matter, doubtless allied to cyanurin, has occasionally been observed in the sweat. Dr. Bleifuss[4] has seen blue sweat from the foot of a patient with disease of the abdomen. Michel has likewise observed it in an hysterical woman and in a hypochondriacal man; it was most marked on the right side of the body. Billard[5] observed a blue sweat on the upper part of the body of a girl.

6th. *Fat* is stated to occur in colliquative hectic sweats.

d. Substances altogether foreign to the animal organism may be conveyed, through the process of digestion, into the blood, and thus occur in the sweat.

Landerer[6] has observed in his own person that after taking large doses of quinine, the sweat assumed the bitter taste of the drug. The following substances enter into, and have been detected in the sweat: sulphur, mercury, iodine, iodide of potassium, assafœtida, garlic, saffron, olive oil, rhubarb, indigo, prussian blue, and copper. (Stark, General Pathology, p. 1127;

[1] Stark, p. 1131. [2] Diss. sing. casum calculositatis. Tub. 1817.
[3] Buchner's Repert. 2d series, vol. 5, p. 234.
[4] Würtemberg. Med. Correspond. Blatt. 1835, No. 26.
[5] Froriep's Notiz. 32. [6] Buchner's Repert. 16, p. 238.

Baumgärtner, Elements of Physiology and Therapeutics, p. 486.)

Many of these statements, regarding the changes undergone by the sweat in disease, are fully confirmed; some must, however, still be regarded as doubtful.

Sweat of animals.

Anselmino has analysed the sweat of the horse, the only animal of whose sweat we have any accurate knowledge. He used for his analysis the scaly matter that falls from horses during the process of currying, in the form of a white powder, and consisting of dried sweat mixed with a considerable amount of dirt and epithelium. It contained, 1st, a substance with an acid reaction, soluble in anhydrous alcohol, alcohol-extract, together with an alkaline lactate or acetate; 2d, an extract-like matter, soluble in alcohol of ·833 and possessing an odour like that of the horse, together with chloride of sodium; 3d, an extractive matter soluble in, and communicating a brown colour to water, and precipitable by infusion of galls, together with chloride of sodium and sulphates. The portion still undissolved evidently consisted of epithelium. Anselmino regarded it as coagulated albumen; doubtless it was in it that the phosphate of lime and magnesia occurred, which were recognised in the ash of the sweat. The ash consisted of sulphates of potash and soda, chlorides of sodium and potassium, a large proportion of the phosphates of lime and magnesia, with traces of iron, but no alkaline carbonates or phosphates. Anselmino seems to have overlooked the ammonia-salts, for it is only by the presence of hydrochlorate of ammonia that we can explain how it is that the ash contains no alkaline carbonate, while the alcohol-extract contains either lactate or acetate of potash. The presence of acetic acid was established by a separate experiment. Fourcroy and Vauquelin sometimes found small quantities of urea in horses' sweat, but Anselmino could never detect it.

Fat.

The minute sebaceous glands (folliculi sebacei) which are distributed over the whole surface of the body, secrete a peculiar fat, which renders the skin supple and flexible, and hinders it from being permeated by water. The composition of this fat varies in different parts of the body, as is clear from the variety of smell which it evolves in the axilla, on the generative organs, on the scalp, and on the feet of many persons. It is usually of a pale yellow colour, not viscid, and insoluble in water, with which, when it is rubbed, it forms an emulsion. It contains relatively only a small amount of true fat, and is associated with several other animal matters, (as, for instance, albumen and extractive matter,) and a considerable amount of inorganic salts. Esenbeck has made an analysis of the fat collected in an enlarged sebaceous gland. It did not coagulate on boiling, and was precipitated by acids, corrosive sublimate, and tannin. It contained in 100 parts:

Stearin	24·2
Extractive matter, with some olein	12·6
Salivary matter	11·6
Albumen with casein (?)	24·2
Phosphate of lime	20·0
Carbonate of lime	2·1
Carbonate of magnesia	1·6
Traces of acetate of soda, chloride of sodium, and loss	3·7

CHAPTER VII.

THE URINE.

The urine is an extremely complex fluid, but the relative proportions of its different constituents are not very variable. The following are the ordinary constituents of healthy human urine: urea; uric acid; [hippuric acid]; extractive matters, embracing alcohol-extract, spirit-extract, and water-extract, with their respective constituents; mucus; brown colouring matter of the urine (hæmaphæin); red colouring matter of the urine (uroerythrin); carbonic, lactic, hydrochloric, sulphuric, phosphoric, silicic, and hydrofluoric acids;[1] soda; potash; ammonia; lime; magnesia; and peroxide of iron.

Recently discharged urine ordinarily possesses the mean temperature of the body; it is of an amber yellow colour, perfectly transparent, has a well-marked acid reaction, and exhales a peculiar but not disagreeable odour, which it loses on cooling. Its specific gravity fluctuates from 1005 to 1030, the average being about 1012·5. It has a saline and disagreeably bitter taste; it undergoes no apparent change upon being heated to the boiling point, and its behaviour towards reagents is dependent upon that of its various constituents, although modified by the very dilute state in which they occur. Acids, with the exception of the oxalic, which produces a turbidity, throw down no precipitates; the free alkalies, on the contrary, throw down the phosphate of lime; the salts of baryta, silver, and lead, cause precipitates; so also does tannin, but in a less degree.

When urine is left to itself for some time, slight nebulæ, consisting of mucus, are formed in it, which gradually descend to the bottom. Soon after the appearance of this phenomenon, an unpleasant odour is developed; instead of an acid, an alkaline

[1] [In addition to these constituents, two new acids, to which no names have been yet assigned, have been described by Pettinkofer and Heintz.]

reaction is observed, and carbonate of ammonia is formed, which causes more or less turbidity by precipitating the ammoniaco-magnesian phosphate, and phosphate of lime. A portion of these salts, associated with mucus, forms a greasy whitish scum, in which, by means of the microscope, beautiful crystals of ammoniaco-magnesian phosphate may be seen, mixed with an amorphous mass of phosphate of lime and decomposed mucus. On treating the urine in this state with hydrochloric acid, it effervesces, in consequence of the presence of carbonate of ammonia. If the urine is allowed to stand for a still longer period, the smell becomes more disagreeable; cubic, and four- and six-sided prismatic crystals, composed of chloride of sodium, hydrochlorate of ammonia, and phosphate of soda and ammonia, are produced in consequence of the concentration produced by the spontaneous evaporation, and the urine ultimately becomes covered with a sort of mould, which is usually of a blue or blueish-gray colour.

We have no certain knowledge regarding the manner in which the acids and bases combine to form salts in fresh healthy urine. We may fairly conclude that the chloride of sodium preexists in it; the sulphuric acid is generally supposed to be united with potash, phosphoric acid with lime and magnesia, and if (as is generally the case) more phosphoric acid be present than is required for the saturation of these earths, the excess combines with soda; and if there be not sufficient soda present to effect the saturation of the acid, the ammonia combines with it, forming the biphosphate of ammonia. The lactic acid of the urine is partly free, and partly combined with ammonia, potash, and soda. Hydrochlorate of ammonia is also supposed to preexist in the urine. Carbonic acid, when it occurs in the urine, is held in solution and in a free state. Uric[1] acid is supposed by Berzelius to exist in a free state in solution in the urine, although warm urine usually holds a larger quantity of uric acid in solution than an equal quantity of water at the same temperature could retain. There is, however, this point in favour of his view, that the uric acid, which separates spontaneously from the urine on cooling, contains mere traces of ammonia

[1] [It is stated in volume I, page 54, that the formula for hydrated uric acid is $C_{10}N_4H_3O_5+HO$. From various analyses of urates by Bensch (Liebig's Annalen, vol. 54, p. 189), there is reason to believe that the true formula is $C_5N_2HO_2+HO$.]

and soda, and he conceives that, in all probability, the uric acid is held in solution through the agency of some of the other constituents of the urine.

[Liebig[1] has shown that uric acid possesses the property of combining with a portion of the soda of the alkaline phosphate of soda, and acquires in the combination a higher degree of solubility than it possesses in its uncombined state, at the ordinary temperature of the body. By this reaction there are produced a urate of soda and an acid phosphate of soda.]

Prout, on the contrary, is of opinion that the uric acid is held in solution in the urine in the state of urate of ammonia, a combination which probably always occurs in healthy urine, and which is often found in large quantity in the urine of diseased persons, giving rise to the formation of sediments. The real state of the case may be, that normal urine contains both free uric acid and urate of ammonia.

Qualitative analysis of healthy urine.

The qualitative analysis of healthy urine seldom presents any great difficulty. Many of its constituents may be detected with ease, unless, as is sometimes the case, they exist in very minute quantity. Others, as for instance, the extractive matters, can only be detected with any degree of certainty by isolating them, in the same manner as is done in quantitative analysis.

The analysis of the urine is something like that of mineral waters; some of the constituents may be at once recognised by the addition of a test, while we can only be assured of the presence of others, by separating them in a distinct and isolated state.

The specific gravity of the urine is most accurately determined by the ordinary 1000-grain glass bottle. An areometer will give the result with less trouble, but, at the same time, with less accuracy.

Becquerel[2] has published a table for the purpose of enabling us to calculate the amount of the solid constituents in a known weight of urine, from the observed specific gravity, [but it has

[1] Lancet, June 1844. [2] Séméiotique des Urines, p. 17.

been proved to give results on which no dependance can be placed.[1]]

1. *Urea.* This constituent seldom occurs so abundantly in the urine, as to be immediately detectible by the addition of any reagent. A portion of urine is usually evaporated in the water-bath to the consistence of a syrup, anhydrous alcohol is added, and the alcoholic solution is filtered, and evaporated on the water-bath nearly to dryness; some drops of water, and subsequently of nitric acid are added, upon which crystals of stellar and foliated shapes very speedily develop themselves.

Upon leaving the alcoholic extract to spontaneous evaporation, long acicular crystals of urea will be formed; on examining some of them under the microscope, they will be found to present the appearance of four-sided prisms, as shown in figure 20, If, (which however is not often the case,) the urea should be present in very small quantity, and no crystals are formed for some time after the addition of nitric acid, it only requires a microscopic examination to ascertain whether the crystals are those of nitrate of urea: if they are, they will occur in the forms indicated in fig. 21. If, instead of nitric, oxalic acid has been used for the detection of the urea, we obtain the forms represented in fig. 22.

2. *Uric acid.* It is but seldom that the uric acid exists in such large amount, as to be precipitated in the form of a fine crystalline red sediment when the urine cools. When, however, this is the case, the crystals, under the microscope, exhibit the rhomboid form shown in fig. 23. Another method of proving that the sediment consists of uric acid, is to place some of it in a porcelain capsule moistened with nitric acid, and to apply heat till the acid evaporates. A purple-red colour then appears, which is characteristic of uric acid: this colour becomes more intense on the approximation of a rod dipped in ammonia. If no crystalline sediment is deposited as the urine cools, two or three drachms of hydrochloric acid must be added to six or eight ounces of urine, and the mixture must be allowed to

[1] [On the specific gravity of the urine in health and disease, especially in diabetes and granular degeneration of the kidneys. By George E. Day. Lancet, June 15, 1844.]

stand, covered, for twenty-four to forty-eight hours. A red or reddish-brown sediment of uric acid then separates, consisting of crystals of the forms represented in fig. 23*a*, and 23*b*.

2*. [Hippuric acid is regarded by Liebig[1] as an invariable constituent of ordinary human urine. "All the urine taken in this country from individuals living upon a mixed animal and vegetable diet, contains hippuric as well as uric acid, and about the same proportion of both acids. Hippuric acid may be obtained in the following manner, even from proportionally small amounts of fresh urine:—Fresh urine is evaporated in a water-bath to the consistence of a syrup; it is then mixed with some hydrochloric acid, and agitated with its own volume of ether, which latter substance dissolves the hippuric acid. It usually happens that the mixture does not separate spontaneously, but that the ether remains inclosed by the fluid, like froth; the separation of the ether takes place immediately upon adding to the mixture, after having allowed it to stand at rest for an hour, one twentieth part of its volume of alcohol. In this case the froth disappears, and the fluid separates into two layers; the upper layer contains the hippuric acid in solution; but besides it also contains urea, owing to the addition of the alcohol. This upper layer is carefully removed by means of a pipette or syphon, and agitated with small portions of water; the water removes the alcohol and the urea, whilst the hippuric acid remains in solution in the ether. By evaporating the ethereal solution the hippuric acid is obtained in crystals. The crystals produced are usually of a yellowish or brown colour, arising from the presence of a resinous substance, which may be easily and completely removed by means of charred blood.[2]

[1] Lancet, June 1844.

[2] [The following is a simple method of obtaining pure crystals of hippuric acid from human urine. Evaporate the urine till there is a copious deposition of salts. Add strong alcohol, and place the mixture in a stoppered bottle. With the aid of a gentle heat, (for instance, by placing the bottle in warm water), we ensure the solution of the urea, the lactates (if any are present) and the hippurates in the alcohol, whilst the urates remain with the insoluble constituents. When the supernatant fluid is perfectly clear, it must be decanted, evaporated very nearly to dryness, and redissolved in hot water. If a stream of chlorine be passed through the aqueous solution, the urea is destroyed; and by gradual concentration, and the addition of a little free mineral acid, we obtain crystals of hippuric acid.]

"In its pure state the hippuric acid produced from human urine presents the same long, shining, transparent, four-sided obliquely-truncated prisms, by which the hippuric acid produced from the urine of animals is so easily detected and distinguished from benzoic acid. (See fig. 23.) The hippuric acid of human urine is not volatile at the subliming temperature of benzoic acid; at a higher temperature it undergoes fusion, forming a brown-red liquid, and yielding upon dry distillation the same products which common hippuric acid forms under the same circumstances, viz., a red-coloured oil smelling like tonka-beans, ammonia, benzoic acid, and a copious residue of carbon. It dissolves in nitric acid at a high temperature, and yields, upon cooling, crystals of benzoic acid, owing to the decomposition which it undergoes.

"From 0·499 of hippuric acid produced from urine, 1·0791 of carbonic acid and 0·2317 of water were obtained. This gives for 100 parts—

	Found.	Calculated.
Carbon . . .	59·47 . .	60·89
Hydrogen . . .	5·15 . .	4·45

This analysis corresponds sufficiently with the calculated results to remove all doubt as to the nature of the acid; it will be perceived that it contains 10% less carbon than benzoic acid."]

3. *Extractive matters.* The exhibition of the divisions of extractive matter, namely, the water-extract, the spirit-extract, and the alcohol-extract, can only be effected by evaporating the urine, and treating it with alcohol, as we shall presently show in speaking of the quantitative analysis of this fluid. Little has yet been done in this department of chemistry, but the presence of the extractive matters can generally be easily recognized by the addition of certain tests: for instance, acetate of copper, chloride of tin, perchloride of iron, and sulphate of protoxide of iron, throw down precipitates from freshly-passed urine; and bichloride of mercury, nitrate of tin, and tannic acid, cause a degree of turbidity. There is, however, no certain proof, although there is every probability that normal urine in all cases behaves in this way with the above tests. The extractive mat-

ters which I formerly separated from the urine were not precipitated by the salts of iron, while, on the contrary, its perchloride throws down a copious precipitate in a specimen of urine, which I am now analysing.

Berzelius states, that after urine has been neutralized by an alkali, precipitates are induced by the salts of zinc, tin, and mercury: I find that fresh urine, with a strong acid reaction, becomes clouded or deposits a sediment upon the addition of these salts.

4. *Mucus.* Mucus in the urine is readily detected by the microscope. We take up with a spoon a portion of the separated nebulous matter, and on placing it on the object-glass we can easily recognize the mucus-granules, and frequently a few epithelium-scales.

5. *Hæmaphæin.* It is this constituent which gives to healthy urine its amber or brownish-yellow colour. The variations in the tints of the urine are dependent upon the quantity of this colouring matter.

[Scharling[1] has recently examined the brown organic matter which gives the colour to inspissated urine, and seems also to be the source of its peculiar odour. By treating urine concentrated by the application of a freezing mixture, with ether, and evaporating, he obtained a brown fusible resinous mass, which he calls *oxide of omichmyle,* and supposes to contain a radical, *omichmyle,* the composition of which is still unknown.

It has a strong odour of castoreum, and when heated smells like urine. It dissolves in alcohol, forming a solution that reddens litmus. It burns with a clear flame, leaving scarcely any ash.]

6. *Uroerythrin.* This red colouring matter exists only in very small quantity in healthy urine, and cannot be easily detected by tests. It is always associated with uric acid, and seems to increase and decrease in the same proportion as that constituent. It is precipitated with the uric acid and urate of

[1] Ann. der Chemie und Pharmacie, vol. 42, p. 265.

ammonia, to the former of which it appears to enact the part of a mild base, imparting to it a more or less deep red colour. This constituent can therefore be detected by the addition of hydrochloric acid to the urine, in the manner already described in speaking of uric acid. In some few diseased states, we find a gray or yellow precipitate of uric acid, as if this constituent was present in large quantity, while the uroerythrin was deficient: on the addition, however, of hydrochloric acid, dark coloured uric acid is soon precipitated.

7. *Carbonic acid* is probably a constituent of healthy urine, existing in a state of solution: in order to detect it, fresh urine must be warmed in a retort, the neck of which rests a few lines under the surface of lime-water. The presence of carbonic acid renders the lime-water turbid. In order to guard against the production of carbonate of ammonia, we must take care that the urine is not submitted to too powerful a heat, and that the distillation is not carried too far.

[The following method is far less liable to give erroneous results. It is founded on the principle that one gas passed through a solution of another will displace it, so that hydrogen or nitrogen will liberate carbonic acid and dissolve in its place. A series of Wolfe's bottles must be arranged, so that hydrogen gas evolved in the ordinary manner from the first shall pass through a strong solution of caustic potash to free it from any carbonic acid that may be mixed with it, and then through another bottle containing lime-water, in order to certify its purity; in the next bottle through the urine to displace the gas dissolved in it, and, finally, through lime-water a second time, to show if the displaced gas were carbonic acid or contained it.]

8. *Lactic acid* is always present in the urine, imparting to it an acid reaction. It may be presumed that the carbonates which are left upon the incineration of the solid residue of the urine correspond to the lactates, because lactates with fixed bases are transformed into carbonates by incineration, and because the other salts which occur in the urine, the sulphates, phosphates, and hydrochlorates, are not similarly changed. It may, however, happen that no carbonic acid is found in the

ash, although there has been a large proportion of lactic acid in the urine; for if the urine contained only free lactic acid, or lactate of ammonia, or even the lactates of soda and potash, at the same time with phosphate of ammonia or chloride of ammonium, the ash might be devoid of carbonic acid, in consequence of the liberated phosphoric or hydrochloric acid uniting with the base.[1]

In this case the lactic acid would have to be determined analytically. The alcohol-extract of the urine contains both free lactic acid and alkaline lactates; after dissolving it in absolute alcohol, precipitating the bases by sulphuric acid, filtering, evaporating the alcohol, dissolving the residue in water, and digesting the acid solution with oxide of zinc, we obtain a lactate of zinc, which may be decomposed by free baryta. This is certainly a very tedious proceeding for the mere qualitative determination of lactic acid, and need never be adopted: since, as far as I am aware, the ash (more especially the ash of the spirit-extract,) always contains carbonates, and as the presence of lactic acid in healthy urine has been sufficiently proved by Berzelius.

[It is well known that Liebig denies the existence of lactic acid and the lactates in the urine; and as the subject has recently attracted much attention, I have thought it advisable to state the grounds upon which that chemist has arrived at his conclusions. "Lactic acid," he observes, "is a non-nitrogenous substance. Nothing has hitherto been observed tending to show that it may be produced from the elements of a nitrogenous substance, by the decomposition of such a substance and the transposition of its elements. In every instance where the formation of lactic acid has been observed, the result of careful examination has proved the presence of a non-nitrogenous substance of an identical, or, at least, similar composition with that acid.

[1] [It has been recently shown by Dr. Golding Bird that an alkaline acetate (and the observation applies equally to a lactate) may exist in a solution of phosphate of soda in considerable quantity, and yet yield no carbonate by ignition. The reaction is explained by the equation:

$$NaO, C_4 H_3 O_3 + HO, 2\,NaO, PO_5 = 3\,NaO, PO_5 + CO_2, HO + C_3 H_3 O.$$

(Lond. and Edin. Phil. Mag., June 1845.)]

"These observations would seem to render the formation of lactic acid in the body of the herbivorous and graminivorous animals, which take starch and sugar in their food (substances from which lactic acid may be formed), not merely possible, but in many cases highly probable; and yet, strange to say, chemists have hitherto attempted in vain to detect lactic acid in the urine of the cow and of the horse. The urine of the cow or horse has no acid reaction; on the contrary, its reaction is strongly alkaline; it contains carbonated, hippurated, or benzöated alkali, or alkalies combined with mineral acids, but no trace of any *lactate*.

"In contrast with this, the urine of man, and of carnivorous animals, manifests, when in a healthy state, a strongly acid reaction. Now, it is precisely in analyses of the blood and urine of man, and of carnivorous animals, that we find lactates mentioned as constant constituents; not because they have in reality been detected in these fluids—for no one has as yet succeeded in producing lactic acid therefrom—but because, upon examining the aqueous and alcoholic extracts of blood and urine, some non-crystalline matters have been found which sometimes manifested an acid reaction, and upon incineration left a carbonated alkali as a residue, thus presenting a remote similarity in deportment to the alkaline lactates.

"From what substance could lactic acid be formed in the body of carnivorous animals? With the exception of fat, they partake of no non-nitrogenous matter in food, no substance, in fact, so far as we know, capable of producing lactic acid. Carnivorous animals partake of no sugar, no starch, no gum, no mucus; there is a total absence of the non-nitrogenous substances which form so large a part of the aliments of herbivorous and graminivorous animals.

"The assumption, *à priori*, that neither the blood nor any other fluid in the body of carnivorous animals can possibly contain any lactic acid, has been positively established by the experiments of Enderlin, (Annalen der Chemie und Pharmacie, vols. 49 and 50.) Finally, Pelouze has proved that the experiments of Henry, who pretended he had detected lactate of urea in urine, are erroneous, and by no means to be relied upon.

"Consequently, as our knowledge of this subject stands at present, the acid reaction of urine cannot proceed from lactic

acid. And although processes of transposition take place in the healthy animal body, rendering insoluble substances soluble in the stomach and bowels, yet these processes are of a different kind from that process of putrefaction of casein in milk which causes the formation of lactic acid.

" Direct experiments prove that fresh urine, of a strongly acid reaction, and taken from various healthy individuals, when cautiously neutralized with baryta water, does not retain in solution the least detectible trace of baryta. Now, as lactate of baryta is readily soluble in water, the urine would certainly, and of necessity, contain baryta, if its acid reaction were really owing to the presence of lactic acid. Upon the addition of the very first drop of the baryta water to urine an extremely copious precipitate is formed; this precipitate contains urate and phosphate of baryta and of lime, but no detectible trace of baryta is found, even although only just so much baryta water is added as to leave the urine still possessing a feebly acid reaction.

" Carbonate of magnesia and calcined magnesia act upon urine in precisely the same manner. If either of these substances be mixed with water, so as to form a milky fluid, and be then added to urine with an acid reaction, the acid reaction will immediately cease, and a very considerable white precipitate be formed. The fluid now manifests a feebly alkaline reaction, and contains a trace of magnesia in solution. It is a remarkable circumstance that magnesia withdraws the phosphoric acid from the urine so completely, that a mixture of perchloride of iron and acetate of potash no longer indicates a trace of phosphoric acid in the urine which has thus been treated with magnesia.

" Had lactic acid been the solvent of the lime and magnesia present in the urine, one would have expected that a corresponding amount of baryta, or of magnesia, would have taken its place upon its separation. But, as I have already observed, not a trace of baryta is found in solution when that substance has been employed for neutralizing the acid, and only a slight trace of magnesia when it has been used for the same purpose.

" But as urine contains a certain amount of alkaline phosphates, i. e. phosphate of soda and phosphate of potash, and as baryta and magnesia form, with phosphoric acid, insoluble

salts, it might have been supposed that the neutral lactates formed upon the neutralization of the urine with the two bases had been decomposed, together with the phosphates of soda and potash contained in the urine, and transposed themselves anew, with these substances, into phosphate of baryta or of magnesia, and into neutral lactate of potash or soda. In this case neither baryta nor magnesia could remain in solution. This circumstance, therefore, renders these experiments indecisive, and leaves the question as to the presence or absence of lactic acid in urine dependent upon more direct experiments.

"I employed putrid urine in my attempts to detect lactic acid, because lactic acid is not destroyed by putrefaction, and it must, therefore, of necessity be present in putrid urine if it really forms a constituent of fresh urine; and because if lactic acid can at all be *formed* by the putrefaction of urine, from matters containing previously no lactic acid, the question whether lactic acid is to be reckoned among the constituents of normal urine is at once practically decided; or, more correctly speaking, the problem is proved to be impossible of solution, since we possess no means of positively determining which urine may be considered of a normal constitution, and, on the contrary, which is, to this extent, abnormal.

"As matters at present stand, therefore, with regard to this subject, it was immaterial whether the presence of lactic acid was detected in fresh or in putrid urine; if it was found to exist in the latter, this fact must be considered as a confirmation of Berzelius' examination of fresh urine; whilst its absence from putrid urine would justify us positively in asserting that it does not form a constituent of fresh urine; and, moreover, that urine contains no substance giving origin, by means of putrefaction, to the formation of lactic acid.

"I have come to the latter conclusion. I have found it impossible to detect the presence of lactic acid in putrid urine; and if we examine somewhat more closely and minutely the experiments made by Berzelius, and from which he inferred the presence of lactic acid in urine, we find that not one of them amounts to a positive proof that lactic acid really forms a constituent of fresh urine.

"The experiments which I made for the purpose of ascer-

taining the presence of lactic acid in putrid urine are the following:

"Putrid urine was first evaporated over an open fire, and afterwards to dryness in a water-bath; the residue was treated with a mixture of alcohol and sulphuric acid, which caused the solution of phosphoric acid, hydrochloric acid, and of lactic acid also, if this latter substance were really present. The fluid obtained was saturated with oxide of lead, and then filtered off from the phosphate, sulphate, and chloride of lead formed; the lead contained in solution in the filtrate was separated by means of sulphuretted hydrogen. The solution thus freed from lead, and which ought to have contained the lactic acid had there been any present, was evaporated in a water-bath, and the residue treated with alcohol: a quantity of common salt remained. In order to remove the soda from the alcoholic solution, effloresced oxalic acid was dissolved in the latter, at a high temperature, and the oxalate of soda formed was separated from the fluid by filtration; the fluid was then saturated with oxide of lead, which again gave rise to the formation and separation of chloride of lead. The solution was, by means of sulphuretted hydrogen, again freed from the lead which had dissolved, then concentrated in the water-bath, and basic acetate of lead added in excess; a copious white precipitate was formed, from which the fluid was filtered off. This fluid must contain the lactic acid if any had been present in the urine; the lead which this fluid held in solution was precipitated by means of sulphuretted hydrogen, the fluid filtered off from the precipitate, concentrated in the water-bath, and boiled with hydrate of baryta: a quantity of ammonia was expelled by this operation. After the decomposition of the ammoniacal salt the new-formed salt of baryta was cautiously decomposed, by means of sulphate of zinc, and every possible means was applied to obtain from this fluid crystals of lactate of zinc, but without success; no trace could be discovered.

"The white precipitate obtained by means of the basic acetate of lead contained hydrochloric acid, and a brown resinous substance, which, upon combustion, comported itself like an animal substance.

"In other experiments the putrid urine was boiled until all the carbonate of ammonia it contained was completely expelled;

then, with addition of hydrate of lime to destroy the remaining salts of ammonia, evaporated to dryness, and the residue treated with cold water, which must have dissolved lactate of lime had any lactic acid been present in the urine. The aqueous extract was evaporated to dryness, and the residue again treated with alcohol; the fluid obtained contained a copious amount of lime combined with an organic acid; the lime was then removed by the addition of oxalic acid, and the excess of oxalic acid by the addition of oxide of lead; the minute trace of dissolved oxide of lead was removed by means of charred blood. The fluid obtained was very acid; it contained hydrochloric acid, which was removed by the addition of oxide of silver; a portion of the fluid filtered off from the hydrochlorate of silver was saturated with oxide of zinc, and left to crystallize, but no lactate of zinc was obtained; the fluid settled into a dark-coloured resinous mass. Another portion of this acid fluid was evaporated in the water-bath; a quantity of acetic acid was expelled during the evaporation, and there remained at last only a very minute amount of a resinous matter, which upon calcination emitted a very fetid odour.

"All the other experiments, which I made in order to detect lactic acid in putrid urine, and a detailed description of which would be as tedious as useless, gave the same negative result. These experiments were usually made upon quantities of from forty to fifty pounds of urine, so that even a very minute amount of lactic acid, if really present in the urine, could not have escaped detection. All these experiments indicated the presence of an organic acid, but after the removal of all the inorganic acids and bases contained in the urine, this acid turned out to be a mixture of acetic acid with a brown resinous substance rich in nitrogen.

"The presence of acetic acid in putrid urine does not warrant us to infer that this acid is present also in fresh urine; on the contrary, the experiments made with regard to this matter prove that fresh urine contains no acetic acid. I have treated it exactly in the same manner as putrid urine, and have, by distillation with oxalic acid, obtained a fluid of a strongly resinous odour, but not possessing any acid reaction. When employing sulphuric acid and hydrochloric acid the distillate was acid, but the acid reaction proceeded from hydrochloric acid."

In the analyses of Lehmann, to which we shall presently refer, the lactic acid is determined quantitatively in a large number of cases. The following independent investigations of Heintz and Pettinkofer are important, as offering a clue to the real nature of the crystals assumed by Lehmann and other chemists, to consist of lactate of zinc.

In the observations of Liebig, quoted above, it is assumed that as lactic acid is not destroyed by putrefaction, it cannot be altered in putrefied urine. Heintz conceived that during the putrefaction of the urine certain causes might prevail to cause the destruction of the lactic acid, and in order to determine the point he instituted the following experiment.

"About fifty pounds of fresh urine, obtained from several young healthy men, were first evaporated over a free fire, and then in the water-bath; the extract obtained exhausted with alcohol, to which a sufficient quantity of dilute sulphuric acid had been added. The acid solution was saturated with oxide of lead, the precipitate filtered, the liquid much evaporated, and the urea contained in this concentrated solution precipitated with pure oxalic acid. A considerable quantity of oxalate of urea was obtained, which, after washing with water and recrystallization, separated in perfectly white, large crystals. The liquid, separated by pressure from the urea, from which it was now almost free, was evaporated to dryness, extracted with alcohol, and effloresced oxalic acid added to the solution to remove the soda. The oxalate of soda was separated by filtration, the filtered solution saturated with oxide of lead, and then precipitated with basic acetate of lead. The lead was removed from the filtered liquid by sulphuretted hydrogen; the filtered solution was concentrated over the water-bath, and boiled with hydrate of baryta, when a considerable disengagement of ammonia resulted. The salt of baryta obtained in solution was decomposed with sulphate of zinc, in such a manner that only a slight excess of this latter remained in the solution. It was then evaporated to a small volume, when some delicate microscopic crystals separated, which were at first taken for lactate of zinc, but on examination under the microscope they soon proved to be distinct. The lactate of zinc, for instance, forms needles with acute dihedral summits, while the crystals of the zinc salt obtained from the urine have truncated terminal sur-

faces. To ascertain more precisely the nature of the acid combined with the oxide of zinc in this salt, the crystals were separated as carefully as possible from the mother-ley, pressed between blotting-paper, dissolved in a large quantity of boiling water, in which they were but sparingly soluble, and allowed to crystallize by cooling. The mother-ley afforded more crystals on further evaporation. They were again separated from adhering liquid by pressure.

"The zinc salt thus obtained had a faint greenish-yellow tint, and was therefore probably not quite pure, although its solution was perfectly colourless. The acid was isolated from this salt by means of sulphuretted hydrogen; after separation of the sulphuret the solution was entirely free from zinc. The liquid, which had a strong acid reaction, was freed by boiling from the excess of sulphuretted hydrogen, and evaporated on the water-bath. When it had become sufficiently concentrated, the acid separated in prismatic crystals, which appeared to form quadrilateral rectangular columns and tables. It is easily soluble in water, and separates in crystals on evaporation; the solution has a strong acid taste, and reddens litmus-paper. It likewise dissolves in alcohol, but not quite so easily as in water; ether dissolves scarcely a trace of it. Heated on platinum foil it melts, becomes brown, and leaves behind a coal, which is difficult of combustion, but which disappears entirely by stronger heat.

"From the mode of preparation it is evident that the acid forms with oxide of zinc a very sparingly-soluble salt, which separates in microscopic crystals. When the acid is supersaturated with ammonia, and the solution evaporated on the water-bath, so much ammonia escapes that it again becomes acid; if it be evaporated to dryness, so that all the ammonia that could escape at this temperature is expelled, and caustic potash be added to the mass, a considerable quantity of ammonia is given off; therefore it appears that this acid, like many organic acids, forms acid salts. The ammonia-salt obtained in this manner is somewhat more difficult of solution in water than the acid itself. When the acid is accurately neutralized with potash, it forms an easily-soluble salt, the solution of which affords no precipitate with sulphate of copper. The oxide of copper is not thrown down from this mixture by an excess of potash, but the colour of the solution becomes somewhat darker. Acetate

of lead produces a slight turbidity, most probably arising from a small quantity of some impurity. No precipitate is obtained with nitrate of silver, and the mixture, after having been rendered ammoniacal, is not altered by boiling. A solution of perchloride of iron, rendered neutral by ammonia, produces no precipitate. It differs, therefore, in this respect from hippuric acid.

"The author has not yet been able to ascertain the composition of this acid, in consequence of the small amount which he obtained from 50 lbs. of urine. It amounted to about eight grains, and was not perfectly white. But it was easy to prove that it contained nitrogen in considerable quantity."[1]

Pettenkofer precipitates the alcoholic extract obtained from carefully evaporated human urine, previously neutralized with carbonate of soda, with a concentrated alcoholic solution of chloride of zinc. A brown amorphous precipitate containing zinc is soon thrown down; but after standing for several hours, small granular and rather hard crystals are deposited on the sides of the glass, which gradually increase to such an extent as to form perfect incrustations. On collecting the amorphous precipitate and the crystals on a filter, and boiling with a sufficient quantity of water, the amorphous precipitate remains insoluble, while the crystals gradually dissolve. On evaporating the aqueous solution a yellow crystalline residue is obtained, which in many of its physical characters resembles lactate of zinc. Under the microscope these crystals appear as very beautiful four-sided prisms, with an oblique terminal surface. They are with difficulty soluble in water, and are insoluble in strong alcohol and ether. In the aqueous solution we may detect chlorine, zinc, and an organic substance very rich in nitrogen. Repeated boiling with strong alcohol, or washing with cold water, removes all the salts (chiefly metallic chlorides) attached to the crystals, and if they are then again dissolved in water and heated with hydrated baryta, the oxide of zinc is precipitated, and carries with it the greater part of the adhering colouring matter. The oxide of zinc and the excess of baryta are then removed as carbonates by passing a stream of carbonic acid through the solution; the filtered liquid which contains chloride of barium and the organic substance is evaporated

[1] Poggendorff's Annalen, lxxii, p. 602.

to dryness in the water-bath; the residue is dissolved in spirit, and sulphuric acid added in order to separate the baryta; filtration is then requisite. The solution, in which sulphuric and hydrochloric acids, and the organic substance, are now contained, is boiled with oxide of lead, which removes the acids; and any excess of lead in the filtered solution is removed by sulphuretted hydrogen. On evaporating the filtered solution in a water-bath we obtain a white crystalline mass, neutral in its reaction, with a slightly bitter pungent taste, and easily soluble in water and alcohol. The addition of bichloride of platinum to the alcoholic solution causes no precipitate, but chloride of zinc throws down a copious white deposit, which, on being dissolved in water and evaporated, reproduces the crystals of the zinc-compound exactly as they crystallized from the urine.

The pure organic substance gave, as the mean of several analyses:

		Calculated.
Carbon . .	39·3	39·2
Hydrogen . .	7·0	6·4
Nitrogen . .	34·0	34·7
Oxygen . .	19·7	19·7

Hence it may be expressed by the formula $C_8H_8N_3O_3$. Human urine emitted in the morning contains about ·5% of this body.][1]

9. *Hydrochloric acid.* The presence of this acid is easily shown. A portion of urine is treated with a little nitric acid, and nitrate of silver is then added, which produces a tolerably abundant curd-like precipitate of chloride of silver.

10. *Sulphuric acid* is always present in healthy urine. On treating a portion with nitric acid, and then adding chloride of barium, a white precipitate or turbidity may be observed, which is due to the formation of sulphate of baryta.

11. *Phosphoric acid* is recognized by the addition of free ammonia to fresh urine; earthy phosphates are immediately precipitated. In order to demonstrate the presence of alkaline phosphates, lime water is added to urine from which the earthy phosphates have been removed by filtration; phosphate of lime

[1] Liebig's und Wöhler's Annalen, vol. 52, part 1.

is then precipitated. Or, after the sulphuric acid has been precipitated with a baryta-salt, ammonia may be added to the filtered fluid, upon which phosphate of baryta will be precipitated.

12. *Silicic acid.* The only method of detecting the existence of this acid is by evaporating the urine, incinerating the residue, dissolving it in water, treating the insoluble portion with hydrochloric acid, and incinerating the residue that still remains. In this way we obtain the silicic acid.

13. *Hydrofluoric acid,* or fluoride of calcium, occurs in very minute traces, and can only be recognized by operating on a very large quantity of urine. The precipitate thrown down by ammonia must be collected, washed, placed in a platinum or porcelain crucible, treated with sulphuric acid, and its action on glass observed.

14. *Soda.* This base is contained in large quantity in the urine, both as chloride of sodium and in combination with acids. Chloride of sodium and the lactates can be removed from the ash of the residue of the urine by spirit; the solution must then be evaporated, and on submitting the salt to the action of the blowpipe, the intensely yellow flame which indicates the presence of soda is perceptible. The presence of soda may be also shown in other ways. Upon treating urine evaporated to the thickness of a syrup with alcohol, the chloride of sodium will dissolve, and by spontaneous evaporation will in part crystallize in the form of octohedra, which are partially perceptible even to the naked eye. These consist of a combination of urea and common salt. Fig. 24 exhibits such octohedra, obtained from evaporated and filtered urine. When the evaporation is conducted rapidly, these forms are replaced by a series of crystals shaped like crosslets and daggers, and usually crenate at the margin. See fig. 24.*. If urine is allowed to stand in a a shallow vessel, until it has become decomposed, and a portion of the urine has evaporated, a crystallized salt will be found, in which prisms and octohedra can be recognized both with the naked eye and with the microscope. The rectangular prisms, fig. 25, exhibit the combination of phosphate of soda with phosphate of ammonia (*sal microcosmicum*).

15. *Potash.* The presence of this substance is detected by dissolving the fixed salts in some hydrochloric acid, extracting them by alcohol, and adding to the alcoholic solution of chloride of potassium some bichloride of platinum: a yellow precipitate of chloride of potassium and platinum is deposited.

16. *Ammonia.* The presence of this substance cannot be very easily demonstrated in healthy urine, on account of the urea and the nitrogenous extractive matters which coexist with it, since the ordinary ammoniacal salts (the chloride of ammonium and the lactate of ammonia) are dissolved with the urea by alcohol; and since, moreover, urea develops ammonia when treated with either free potash or its carbonate in just the same manner as the ammoniacal salts. The following method appears to me to be the most appropriate: Evaporate the alcohol-extract of urine, dissolve a portion of it in water, and add a solution of caustic baryta. If ammoniacal salts are present, a strong odour of ammonia will be developed. Neither pure urea, nor the nitrate, on being similarly treated, gives off this ammoniacal odour.

[Healthy urine, according to Liebig,[1] contains only very minute or doubtful traces of ready-formed ammonia, and these traces probably pre-existed, in the food partaken of. Fresh urine evolves ammonia when treated with alkalies, but it yields no precipitate with bichloride of platinum. Dr. Schlossberger made certain experiments to this effect in the laboratory at Giessen; upon treating fresh urine with bichloride of platinum, and allowing the mixture to stand at rest during the night, crystals were formed in the urine, which, upon examination, manifested all the properties of chloride of platinum and potassium. The amount of ammonia formed in the healthy organism is likewise very minute, not being sufficient even to neutralize the acid from which proceeds the acid reaction of urine and of saliva. We cannot assume the presence of any ammoniacal salt in the urine of herbivorous animals, which contains fixed or alkaline carbonates.

Experiments for the determination of the amount of ammonia

[1] Lancet, June 1844.

in the urine of healthy individuals may become of importance in judging of pathological states; for in fevers and other diseases the amount of ammonia in the urine increases considerably. It is possible that, by analysing the urine, we may, in the increasing or decreasing amount of ammonia, obtain a measure for the alterations which take place in diseases. But the salts of potash, which are rarely absent, as well as the ammonia which is formed by the action of bichloride of platinum upon the organic constituents of urine, render this reagent (the bichloride of platinum) very unsafe for determining the increasing or decreasing amount of ammonia in the urine during disease. The magnesia salts would, perhaps, answer this purpose better; the determinative examinations made with salts of magnesia are inferior to those made with bichloride of platinum, but they are exact enough for the purpose of comparison.]

17. *Lime.* There is no difficulty in proving the existence of lime in the urine. On adding oxalate of ammonia to fresh urine, a nebulous turbidity of oxalate of lime is formed. If the urine is somewhat concentrated by evaporation, a precipitate is obtained which appears under the microscope as an amorphous mass.

When urine is allowed to stand till ammonia is developed, phosphate of lime and ammoniaco-magnesian phosphate are precipitated. The phosphate of lime may be recognized under the microscope as an amorphous mass: sometimes, but rarely, it occurs in a crystalline form. Both varieties are exhibited in fig. 26.

18. *Magnesia.* The lime having been precipitated as an oxalate, and free ammonia added to the filtered urine, ammoniaco-magnesian phosphate will then be deposited. We have already observed that this salt becomes spontaneously formed, if urine is allowed to stand for some time, in consequence of the development of ammonia. A thin film may then be seen on the surface, in which we may detect minute crystals, even with the naked eye. The inner surface of the vessel is also covered with a crop of similar crystals. Under the microscope the ammoniaco-magnesian phosphate may be recognized by the peculiar crystalline form represented in fig. 27.

19. *Peroxide of iron.* The amount of iron contained in the urine is frequently very minute, and can only be detected in the ash, which must be dissolved in hydrochloric acid. Upon the addition of ferrocyanide of potassium to the acid solution, a deep blue colour, or a very slight precipitate of prussian blue is produced: while the addition of hydrosulphate of ammonia or infusion of galls effects a dark colouring.

QUANTITATIVE ANALYSIS OF THE URINE.

Method of separating all the proximate constituents.

An exact quantitative determination of all the constituents of the urine is a task beyond the powers of animal chemistry in its present condition. Our ignorance of the proximate constituents of the extractive matter, and our inability to separate them, are alone sufficient to preclude the hope of a perfect analysis: we must therefore content ourselves with pursuing the same course as we have already done with the blood, and must rest satisfied with effecting the separation (as accurately as we can) of those constituents which at present we regard as the most important, and which present no peculiar chemical difficulty; whilst others, as for instance the various extractive matters, must be associated in groups.

Even this abbreviated and comparatively simple method does not yield absolute estimates, only a few of the constituents of the urine, as, for instance, the fire-proof salts, yielding quantitative results with analytical exactness: the determination of the organic constituents,—of the urea, uric acid, ammonia-compounds, and extractive matters is more or less insecure and fluctuating, and we must regard a quantitative analysis of urine as giving us certainly an idea of its probable constitution, but not by any means of its actual composition.

I shall now explain a method of analysing the urine, by which the principal constituents may be isolated and determined.

It is impossible to estimate the various constituents of the urine from a single portion; different portions of the same urine must be used for the determination of the various constituents, as will be presently shown.

The urine to be examined must be tested with litmus paper, in order to ascertain the presence or absence of free acid. Healthy urine is generally acid, seldom neutral. If the urine is turbid, it must be examined under the microscope; the presence of mucus can be the only cause of turbidity in healthy acid urine. The specific gravity of the urine is best estimated by the 1000-grain bottle.

The quantity of urine to be analysed must be carefully weighed, or the amount contained in the 1000-grain bottle (the contents of which are exactly known when the stopper is inserted,) may be taken. A small portion always adheres to the glass upon pouring it out, the quantity of which can be ascertained by weighing.

1. *Determination of the free acid.*

A known quantity of warm urine must be treated with tincture of litmus in which the excess of free alkali has been neutralized by acetic acid, so as to leave a perceptible red tint. Dilute solution of ammonia must then be added by drops, and with constant stirring, until the red colour begins to merge into a blue. The quantity of ammonia required for this purpose is estimated by weight, or, if a graduated vessel is used, by measure. From our knowledge of the quantity of ammonia in the solution, we can estimate the quantity of free lactic acid.

2. *Determination of the water and vesical mucus.*

From 500 to 1000 grains of urine must be filtered; the mucus which remains on the filter must be washed with water, dried, and weighed with the filter, the weight of which should have been previously determined. The filtered urine must be evaporated in the water-bath to the thickness of an extract, and then placed (in its basin) in a receiver over sulphuric acid, in order to be thoroughly dried. The residue when dried must be weighed with the basin, and the water estimated by the loss of weight.

3. *Determination of the urea.*

The dry residue of (2) is moistened with a sufficient quantity of water to reduce it to an uniform extract; it is then thoroughly

exhausted with alcohol of 0·83; the alcoholic solution is evaporated in the water-bath to a state of dryness, and the residue extracted with anhydrous alcohol. The anhydrous alcohol is evaporated at a very gentle temperature; the residue is dissolved in a little water, and cold nitric acid (perfectly free from nitrous acid) added to it. The basin is then placed for some hours in snow, or in an artificial freezing mixture. The moist nitrate of urea is collected upon a filter, which is enveloped in the folds of thick blotting-paper, and pressed, as long as fresh blotting-paper continues to absorb moisture. The filter, which, with its contents, is now nearly dry, is exposed to a temperature of from 104° to 122°, and then quickly weighed. The known weight of the filter is deducted from the weight of the filter and its contents, or, which is better, the nitrate of urea is separated very carefully from the filter, again dried, (since it readily absorbs moisture,) and weighed. From the nitrate we estimate the quantity of urea.[1] (See Vol. I, p. 52.)

4. *Determination of the uric acid.*

Three or four ounces of urine must be treated with three or four drachms of hydrochloric or nitric acid, and allowed to rest

[1] [Marchand has recently examined the combinations of urea and nitric acid, and has arrived at conclusions very different from those of other observers. He used nitrate of urea, which was precipitated from its solution by the addition of nitric acid. It was pressed between folds of bibulous paper, and dried at 240°. Its aqueous solution was digested with carbonate of baryta, and the nitrate of baryta decomposed by sulphuric acid. The nitric acid amounted to 60·66 per cent.; hence the compound consisted of $C_2H_4N_2O_2+2NO_5+HO$. A portion was heated to 284°; it then yielded a quantity of sulphate of baryta corresponding to 65·72 per cent. of nitric acid. It had probably become anhydrous, for in that state it would contain, by calculation, 64·3 per cent. As the neutral nitrate of urea was not obtained in this manner, Marchand dissolved the acid compound in water, and added urea. The dried crystalline compound now obtained contained 55 per cent. of nitric acid, and was therefore composed of $2C_2H_4N_2O_2+3NO_5+HO$.

When the liquid from which the above-mentioned salt crystallized was treated with urea and the solution again crystallized, he obtained a compound which lost no weight at 230°, and after being exposed for some time to this temperature, contained 44·1 per cent. of nitric acid. He concludes by observing that the compound usually separated in analyses does not contain the amount of urea stated in the text, but only 33·89 per cent. Marchand further states that crystallized oxalate of urea contains three atoms of water, two of which (14·6 per cent.) escape at 248°, while the third is retained till decomposition ensues. (Journ. für prak. Chem. Feb. 1845.]

for from 36 to 48 hours. Uric acid crystals of a whitish-gray, or more commonly of a red colour, deposit themselves from this acid urine, partly at the bottom and partly on the sides of the glass. The mass of the clear supernatant fluid must be poured off, the crystalline coating is then loosened from the sides of the vessel, and collected on a small filter. When all the uric acid is collected on the filter, and the whole of the fluid has run through, a little water is sprinkled over it, and the filter is then dried and weighed. By subtracting the known weight of the filter, we obtain the amount of uric acid.

5. *Determination of the water- and spirit-extracts.*

From 1000 to 2000 grains of filtered urine are evaporated on the water-bath, and the residue treated with alcohol of 0·83, which throws down the water-extract, as well as the sulphates and phosphates. These are collected upon a weighed filter, and washed with alcohol of similar strength. The filter with its contents is weighed, and by deducting the known weight of the filter, we obtain the weight of the water-extract and salts. By incineration of the filter and its contents, there are left only the sulphates and phosphates; the water-extract is, therefore, estimated by the loss.

Whatever is dissolved by the alcohol of 0·83 is mixed with the spirit used for washing, and the fluid gently evaporated on the water-bath until an extract-like residue is left; this, after being allowed to cool, (during which process it usually becomes solid,) is treated with cold anhydrous alcohol. In this way the spirit-extract, as well as chloride of sodium, and a portion of the alkaline lactates, if any are present, are separated. The basin is kept as cool as possible, and repeated additions of absolute alcohol are made, in order to see whether the alcoholic solution which has become clear after settling, still becomes turbid, and if so, a certain quantity of anhydrous alcohol must again be added. When the alcoholic fluid (A) is perfectly clear, it is decanted from the residue of salts, which is washed with anhydrous alcohol, cautiously dried on the water-bath, weighed, and estimated as spirit-extract with salts. By a thorough incineration we can determine the spirit-extract by the loss of

weight. The following salts remain: chloride of potassium, chloride of sodium, and carbonate of soda; the latter corresponding with the lactates.

6. *Determination of the alcohol-extract, the lactate of ammonia, and chloride of ammonium.*

These are the most difficult constituents to determine. I proceed in the following manner: the alcoholic fluid (A) obtained from the precipitation of the spirit-extract, is evaporated on the water-bath to the consistence of a thick syrup, and after being thoroughly dried over sulphuric acid in a receiver, is weighed. The residue is dissolved in a little water, and free baryta gradually added, a gentle warmth being kept up as long as it continues to dissolve, and as long as ammonia is perceptibly evolved. This point being attained, the mixture is evaporated to the consistence of an extract, and moistened with a little alcohol of 0·83; a large quantity of anhydrous alcohol is then added, and the whole allowed to clear itself. There remain undissolved, chloride of barium, a compound of baryta with extractive matter, and the greater part of the free baryta, which has probably been added in excess. Dissolved in the alcohol are urea, lactate of baryta, and a small quantity of free baryta. The undissolved portion is burnt in a platinum crucible, the residue incinerated, and the ash digested in water. The solution must be filtered, slightly acidulated with nitric acid, and the chlorine then precipitated by nitrate of silver. The chloride of ammonium can be calculated from it.

The alcoholic solution must be evaporated, the residue dissolved in water, the solution filtered, and a current of carbonic acid passed through it, until the free baryta is precipitated: it must then be again filtered, acidulated with nitric acid, and the baryta of the lactate of baryta precipitated by sulphuric acid. The lactate of baryta must be estimated from the residual sulphate.

By subtracting from the solid residue of the alcohol-extract the weight of the urea, of the free lactic acid, of the lactate of ammonia, and chloride of ammonium, we obtain the quantity of the alcohol-extract.

7. Determination of the fixed salts.

The determination of these constituents is of much importance; they are composed of potash, soda, lime, magnesia, sulphuric acid, phosphoric acid, and hydrochloric acid. The determination of the silicic acid would also be interesting, if a series of analyses in reference to this point were instituted. Iron, manganese, and fluoride of calcium exist in too minute quantities to be successfully determined, or indeed always detected. The bases and acids which were first named, viz. the potash, &c., may be determined in the following manner. Three or four ounces of urine are evaporated, and the residue incinerated. As the carbonaceous matter does not readily burn off, in consequence of being entangled with the melting salts, it is expedient to add some nitric acid to the urine, and to place a cover on the crucible. A white melted ash is soon obtained, the weight of which must be determined. A certain proportion of this ash, if the whole quantity is sufficiently large, may be weighed, and used for the determination of the chlorine, or a separate quantity of urine may be evaporated and incinerated for this purpose.

For the determination of the other constituents a known quantity of the salts is dissolved in water, to which a little nitric acid has been added; this solution (A) is filtered; what remains on the filter is silicic acid, mixed perhaps with a little carbon. It must be washed, burnt with the filter, and its weight estimated. The solution (A) and the water with which the contents of the filter were washed, are mixed together, and a slight excess of free ammonia added. The mixture is then warmed. By this means the earthy phosphates are precipitated, and, as in healthy urine the phosphoric acid is in excess as compared with the earths, the latter are completely thrown down. They are quickly washed, dried, exposed to a strong heat, and weighed. In order to determine the quantity of lime in the earthy phosphates, they must be dissolved in very diluted nitric acid, and the free acid saturated with ammonia; the lime may then be precipitated by oxalate of ammonia. The filtered fluid will yield the magnesian salt, by precipitation with free ammonia.

The ammoniacal solution from which the earthy phosphates have been precipitated must be mixed with the water used

for washing the precipitate, and super-saturated with nitric acid. A solution of chloride of barium must be added, as long as any sulphate of baryta continues to be precipitated. The fluid is then warmed, for the more perfect separation of the sulphate of baryta, which is collected on a filter, washed, exposed to a strong heat, and weighed. By this means the sulphuric acid contained in the urine is calculated. The acid solution from which the sulphuric acid has been precipitated is mixed with the water used for washing the precipitate in a stoppered bottle of such a size as to be nearly filled by it; it is rendered alkaline by caustic ammonia, and chloride of barium is added to it, as long as phosphate of baryta is precipitated. The bottle must be allowed to stand, with the stopper in it, until the precipitate is completely deposited. The fluid is then poured off, and the precipitate washed out on a filter with a little weak solution of ammonia. It is dried, exposed to a strong heat, and weighed. The phosphoric acid must be calculated from the phosphate of baryta thus obtained. The ammoniacal fluid from which the sulphuric and phosphoric acids have been removed by baryta is mixed with the fluid with which the last precipitate was washed; they are evaporated, the residue treated with sulphuric acid, and then submitted to a high temperature to expel any excess of the acid. The fixed alkalies remain in combination with sulphuric acid. If these salts are dissolved in water, and chloride of barium added to the filtered solution as long as sulphate of baryta continues to be precipitated, the chlorides of potassium and sodium are left in the solution, from which they may be separated and estimated.

The chlorine is determined, as I have already remarked, by a separate experiment. A known quantity of the fixed salts is dissolved in water, and a little nitric acid added to the filtered solution; upon the addition of nitrate of silver, a curdy precipitate of chloride of silver is thrown down.

The proximate constituents of the fixed salts being thus determined, we have next to consider how they are combined. The sulphuric acid is associated with the potash, and if there is not a sufficient quantity of potash, with as much soda as will make up the deficiency: the rest of the soda is allotted to the hydrochloric and phosphoric acids. If there is more than suf-

ficient potash to combine with the sulphuric acid, the excess is united with hydrochloric acid.

If the urine-salts froth very much upon being treated with an acid, and if we find that after combining the potash and soda with sulphuric, hydrochloric, and phosphoric acids some soda is still left, this must be reckoned as lactate of soda. The earths occur as earthy phosphates.

The fixed salts may likewise be determined from the residue obtained in the investigation of the water- and spirit-extracts, (see 5,) by exposing it to a strong heat; and we are sometimes driven to this course of proceeding in consequence of having only a small quantity of urine to analyse. This method of determining the salts is, however, unsafe, in consequence of a portion of the lactate of soda being dissolved by the anhydrous alcohol, and because, farther, small quantities of the phosphates and sulphates are always associated with the chlorine-compounds. In adopting this method, we must determine the earthy phosphates and the alkaline sulphates and phosphates, from the water-extract; and the chlorine, with minute quantities of the sulphates and phosphates, from the saline residue of the spirit-extract.

In the determination of the urinary salts from the fixed residue, it becomes a matter of importance to ascertain whether the organic constituents do not contain a certain amount of sulphur and phosphorus, which increase the quantity of the sulphates and phosphates found after incineration. From an experiment, I am led to conclude that this is not the case. I determined the earthy phosphates, and the alkaline sulphates and phosphates, in three ounces of filtered healthy urine, and found earthy phosphates, 0·5; sulphate of potash, 2·45; phosphate of soda, 1·16. From the fixed salts of three ounces of the same urine I obtained, earthy phosphates, 0·52; sulphate of potash, 2·48; and phosphate of soda, 1·16.

A shorter method of separating the most important constituents of the urine.

Isolated and unconnected analyses of urine are of very little value in physiological and pathological chemistry. In proportion to the number of analyses made according to one uniform method, is the value of each individual analysis increased. It

would obviously require an immense sacrifice of time and labour to institute a series of urinary analyses upon the plan that we have already laid down; our trouble will be much diminished by agreeing which of the constituents are to be considered as the most important, and devoting our attention to them alone. We do not by any means wish to imply that elaborate analyses, made on the system we have described, are not more valuable than those conducted according to a simpler scheme; we only wish it to be understood that a shorter method will give results that will fully answer many of our proposed ends.

A shorter method may be properly limited to the determination of the solid constituents of the urine, the quantities of urea and uric acid, of the fixed salts collectively, and, from them, of the earthy phosphates and alkaline sulphates and phosphates individually, and ultimately of the remaining constituents, as lactic acid, extractive matters, and the compounds of chlorine and ammonia.

With this view we determine

a. The specific gravity of the urine in the ordinary manner;

b. The quantity of solid constituents, and of the urea, according to the method described in 2 and 3, from a weighed and evaporated portion of urine;

c. The quantity of uric acid, according to the method given in (4), by the addition of hydrochloric acid to a certain quantity of urine;

d. The quantity of extractive matters and ammonia-salts, by evaporating a known quantity of urine and incinerating the residue. The amount of solid residue being known from *b*, we subtract from it the fixed salts which have been thus obtained as a residue after incineration, the urea (*b*), and uric acid (*c*); the difference corresponds with the extractive matters and ammonia-salts;[1]

e. The fixed salts are known by the weight of the residue in *d*; they may be easily burnt white by the addition of a little nitric acid. From these salts we can determine,

f. The amount of earthy phosphates, and alkaline phosphates and sulphates, by the method described in 7.

[1] This estimate must be always rather too high, in consequence of the alkaline lactates being converted into carbonates in the process of incineration.

ON THE COMPOSITION OF NORMAL URINE.

Berzelius[1] published an analysis of healthy urine in the year 1809, which was, till a very few years ago, the only one that gave a correct view of the constitution of so important a secretion. He does not state anything about the circumstances under which the urine was voided, or in regard to the person from whom it was taken. 1000 parts contained:

Water	933·00	
Solid residue	67·00	
Urea	30·10	
Uric acid	1·00	
Free lactic acid, lactate of ammonia, alcohol- and water-extract	17·14	
Mucus	0·32	
Sulphate of potash	3·71	Fixed salts. 15·29
Sulphate of soda	3·16	
Phosphate of soda	2·94	
Biphosphate of ammonia	1·65	
Chloride of sodium	4·45	
Chloride of ammonium	1·50	
Phosphate of lime and magnesia	1·00	
Silicic acid	0·03	

I have made two analyses of the urine of a healthy man, aged 33 years, of a decidedly sanguineous temperament, whose digestion and nutrition were not very good. 1000 parts contained:

	Analysis 93.		Analysis 94.	
Specific gravity	1011		1012	
Water	963·20		956·00	
Solid residue	36·80		44·00	
Urea	12·46		14·578	
Uric acid	0·52		0·710	
Alcohol-extract, with free lactic acid	5·10	Extractive matter and ammonia-salts. = 10·14	4·800	Ext. mat. & amm.-salts. = 12·94
Spirit-extract	2·60		5·590	
Water-extract and vesical mucus	1·00		2·550	
Lactate of ammonia	1·03			
Chloride of ammonium	0·41			
Chloride of sodium	5·20	11·19	[2] 7·280	13·77
Sulphate of potash	3·00		3·508	
Phosphate of soda	2·41		2·330	
Phosphates of lime and magnesia	0·58		0·654	
Silicic acid	a trace		a trace	

[1] Thierchemie, p. 458.

[2] This includes the lactate (carbonate) of soda and a little sulphate of potash.

I have analysed the urine of the same man upon three other occasions under the following circumstances. *A* represents urine passed upon rising in the morning, after having drunk several glasses of water the previous evening. After drinking coffee and a glass of water, such violent exercise was taken for two hours, that the pulse rose to above 100, with occasional intermissions; the urine *B* was then voided. Half an hour afterwards the urine *C* was discharged. In all three cases the urine was clear, *B* being the most slightly tinged. They all had an acid reaction, that of *C* being the strongest, and of *B* the weakest. The analyses, in which, however, all the proximate constituents were not determined, gave the following results:

	Analysis 95. *A.*	Analysis 96. *B.*	Anal. 97. *C.*
Specific gravity	1010	1008	1014
Water	972·600	981·000	957·600
Solid residue	27·400	19·000	42·400
Urea	8·402	7·568	15·257
Uric acid, extractive matter, ammonia-salts, and chlorine compounds	13·960	8·618	19·140
Phosphate of soda	1·850	1·250	2·750
Sulphate of potash	2·790	2·200	5·000
Phosphates of lime and magnesia	0·479	0·264	0·656

C. G. Lehmann has likewise made some very minute analyses of the healthy urine of a young well-fed man, [himself in fact.] These analyses approximate closely in their results to those of Berzelius. They were made with the collected urine of the past twenty-four hours. The concentration of the fluid may be explained by the circumstance of the young man by whom the urine was passed, taking only a very little drink, as is the usual habit with persons of the sanguineo-bilious temperament.

	1.		2.		3.	
Water	937·682		934·002		932·019	
Solid residue	62·318		65·998		67·981	
Urea	31·450		32·914		32·909	
Uric acid	1·021		1·073		1·098	
Lactic acid	1·496		1·551		1·513	
Water-extract	0·621		0·591		0·632	
Spirit- and alcohol-extract	10·059		9·871		10·872	
Lactates	1·897		1·066		1·732	
Chlorides of sodium and ammonium	3·646	15·857	3·602	15·744	3·712	16·130
Alkaline sulphates	7·314		7·289		7·321	
Phosphate of soda	3·765		3·666		3·989	
Phosphates of lime and magnesia	1·132		1·187		1·108	
Mucus	0·112		0·101		0·110	

Christison[1] published an analysis of healthy urine, in which, however, he did not enter into very minute details. The specific gravity was 1029. In 1000 parts, he found 67·7 of solid residue, of which 55·2 were composed of urea, extractive matters, and lactates, 11·1 of alkaline chlorides, sulphates and phosphates, 1·0 of earthy phosphates, and 0·4 of mucus. Hence 100 parts of the solid residue contain about 40 urea, 16 fixed salts, 39 extractive matters and ammonia-salts, and 1·5 earthy phosphates.

Dumenil made an analysis of urine in 1826. He found the specific gravity of the mixed urine of several healthy persons to be 1016.

In 1000 parts there were 31·8 of solid residue, which consisted of 13·2 parts of urea not quite free from alcohol-extract, 0·08 of uric acid, 2·09 of extractive matter, 0·6 of earthy phosphates, 1·03 of phosphate of soda, 0·55 of phosphate of ammonia, 2·69 of sulphate of potash, 8·03 of chloride of sodium, 2·69 of sulphate of potash, 8·03 of chloride of sodium, 1·16 of chloride of ammonium, 0·18 of phosphate of lime, peroxide of iron, and sulphate of lime, and 0·39 of mucus.

[In addition to these analyses we may mention those of Becquerel, Marchand, and myself. Becquerel obtained the following results:

	Mean composition of urine of 4 healthy men.	Ditto of 4 healthy women.	General mean.
Specific gravity	1018·9	1015·12	1017·01
Water	968·815	975·052	971·935
Solid constituents	31·185	24·948	28·066
Urea	13·838	10·366	12·102
Uric acid	0·391	0·406	0·398
Fixed salts	7·695	6·143	[2] 6·919
Organic matters	9·261	8·033	8·647

[1] Edin. Med. and Surg. Journal, vol. 33.

[2] [These salts consisted of:

Chlorine	0·502
Sulphuric acid	0·855
Phosphoric acid	0·317
Potash	1·300
Soda, lime, and magnesia	3·944]

Marchand's[1] analyses correspond very closely with those of Lehmann. He cites the two following analyses as representing the composition of the healthy secretion:

Water	933·199	938·856
Solid constituents	66·801	61·144
Urea	32·675	30·321
Uric acid	1·065	1·001
Lactic acid	1·521	1·362
Extractive matters	11·151	10·553
Mucus	·283	·201
Sulphate of potash	3·587	3·201
Sulphate of soda	3·213	3·011
Phosphate of soda	3·056	2·998
Biphosphate of ammonia	1·552	1·231
Chloride of sodium	4·218	4·001
Chloride of ammonium	1·652	1·231
Phosphates of lime and magnesia	1·210	1·001
Lactates	1·618	1·032

The following table gives the mean result of six analyses of the morning urine of a healthy man, instituted by myself.[2]

Specific gravity	1022·5
Water	961·00
Solid constituents	39·00
Urea	16·60
Uric acid	·61
Fixed salts	9·27
Organic matter and loss	12·07]

The apparent discrepancies in the composition of healthy urine, as shown in the analyses that have been quoted, depend for the most part on the fluctuating amount of water. If we calculate the proximate constituents of the urine in relation to an equal amount of solid residue, we shall find these differences exhibited in a much less striking manner, although to a certain degree they still exist.

100 parts of the solid residue of the urine contain—

[1] Lehrbuch der physiologischen Chemie, p. 292. [2] Lancet, Feb. 1844.

	Berzelius.	Lehmann. 1.	Lehmann. 2.	Lehmann. 3.	Simon. 93.	Simon. 94.	Simon. 95.	Simon. 96.	Simon. 97.	Marchand. 1.	Marchand. 2.	Day.
Urea	45·10	49·68	48·39	49·10	33·80	33·10	30·07	37·80	36·20	48·91	49·58	42·56
Uric acid	1·50	1·61	1·57	1·63	1·40	1·60				1·59	1·63	1·56
Extractive matter, ammonia-salts, and chloride of sodium	36·30	28·95	25·80	29·54	42·60	46·00	50·90	47·90	47·37	32·49	31·74	
Alkaline sulphates	10·30	11·58	10·71	10·92	8·14	8·80	10·01	11·00	12·00	10·18	10·15	
Alkaline phosphates	6·88	5·96	5·38	5·65	6·50	5·70	6·75	6·25	6·80	4·57	4·90	
Phosphates of lime and magnesia	1·50	1·97	1·73	1·65	1·59	1·50	1·75	1·46	1·62	1·81	1·63	

On the physiological relation of the urine.

[The following observations of Liebig on the influence of the salts contained in the food, upon the composition of the urine are well worthy of consideration.

"The alkaline reaction of the lymph, chyle, and blood of man, and of the carnivorous animals, cannot be owing to the presence of a free alkali; for the nutriment of man, and of the carnivorous as well as the graminivorous animals, contains no free alkali, nor any salt formed of an alkaline base and an acid which might be destroyed in the organism, by the vital process, and thus cause the alkaline base to be liberated. The blood must contain the same salts as exist in the aliments. With the exception of common salt, nothing is added during the digestion of the aliments. We have seen that this substance undergoes decomposition in the upper part of the digestive apparatus, being resolved into free soda and free hydrochloric acid; but we have also seen that the liberated soda rejoins the hydrochloric acid during the preparation of the chyme, and previous to the transformation of the latter into chyle;[1] that is, when the acid has performed its function, namely, the solution of the aliments; the salt formed by this combination, that is, common salt, has neither an acid nor an alkaline reaction. The salts with an alkaline reaction contained in meat, flour, or grain, are alkaline phosphates. Hence it is obvious that the alkaline reaction of the chyle, lymph, and blood of animals feeding upon animal and vegetable substances, can only be derived from their alkaline phosphates.

"The bibasic phosphates of soda and of potash are, in many respects, highly remarkable salts; although of a tolerably strong alkaline reaction, yet they exercise no destructive action upon the skin or upon organic formations; they possess all the properties of the free alkalies without being such; thus, for instance, they absorb a large amount of carbonic acid, and this in such a manner that acids produce effervescence in a saturated solution of this kind, just as they would in alkaline carbonates; they dissolve coagulated casein, as well as coagulated albumen, into clear fluids, with the greatest facility, just as caustic or carbonated alkalies do. But of still greater importance in relation to the secretion of urine is their deportment towards hippuric and uric acids. Hippuric acid dissolves with the greatest facility in water to which common phosphate of soda has been added; uric acid possesses the same

[1] Liebig's Animal Chemistry, 2d edit. p. 112.

property at a high temperature; the phosphate of soda, in this process, loses its alkaline reaction completely upon the addition of uric and hippuric acids, and assumes an acid reaction. The acid nature of the urine of man, and of the carnivorous and graminivorous animals, is thus explained in a very simple manner.

"There are but two principal channels through which the salts entering the organism with the aliments can effect their exit from the body; viz., they must either be carried off in the fæces or in the urine. The most simple experiments show that soluble salts are carried off by the fæces only when the amount of salt contained in the fluids in the intestines is larger than that contained in the blood; if the amount of salt in these fluids is equal or inferior to that of the blood, the soluble salts are reabsorbed by the absorbing vessels of the intestinal tube, and enter the circulation, and are then removed from the body by the urinary organs and channels. If the amount of salt contained in the intestinal tube is larger than that contained in the blood, the salts exercise a purgative action.

"If, after previous evacuation of the rectum, a weak solution of common salt (one part of salt to sixty parts of water) be taken by means of a clyster, no second evacuation will take place; the fluid is absorbed, and all the salt is found in the urine. This experiment yields the most convincing results if ferrocyanide of potassium is substituted for common salt; in this case, the first urine excreted after the injection of the saline solution, and frequently even after so short a time as fifteen minutes, contains so large an amount of ferrocyanide of potassium as to yield, upon the addition of persalts of iron, a copious precipitate of Prussian blue.

"The influence which salts in general exercise upon the secretion of urine is, in the highest degree, worthy of attention. It is a well-known fact that a very speedy emission of urine takes place, in healthy individuals, after drinking fresh pump-water. If ten glasses of water, of from six to eight ounces each, containing no more than 1-500th of its amount in salts, be drank at short intervals, an emission of urine of the usual colour will, after the lapse of about ten minutes, follow the second glass, and from eight to nine evacuations of urine will generally occur in the course of an hour and a half. The

urine, in this experiment, emitted in the last evacuation, will be clear and colourless, like pump-water, and the amount of salts it contains is little more than is contained in pump-water. There are individuals who are capable of thus imbibing from six to eight quarts of water consecutively without any inconvenience.

"But the case is quite different with water possessing an amount of salts equal to that of the blood; if even as little as 1-100th part of common salt be added to pump-water, and from three to four glasses drunk, no evacuation of urine will take place, even two hours after drinking. It is almost impossible to drink more than three glasses of this saline water, for it weighs heavily on the stomach, as if the absorbent vessels had no power of taking it up. This obviously arises from the fluid within the channels of circulation, i. e. the blood, and the fluid without these vessels, i. e. the saline water, not exercising any physical action upon one another, i. e. not intermixing by endosmose or exosmose.

"Water containing a larger amount of salts than the blood, such as common sea-water, for instance, and even the weaker kinds of saline mineral waters, exercise again a different action from that of pump-water mixed with 1-100th of common salt; not only no emission of urine takes place after the imbibition of such saline water, but water exudes from the circulating vessels into the intestinal tube, and, together with the saline solution, is carried off through the rectum; purgation takes place, attended with much thirst, if the saline solution be in some measure concentrated.

Considering that a certain amount of salts is absolutely necessary to constitute normal blood, we may deduce from these observations and experiments (which any one may easily imitate and verify upon his own person) that the physical condition of the tissues or of the blood-vessels opposes an obstacle to any increase or decrease of the amount of salts in the blood; and thus that the blood cannot become richer or poorer in salts beyond a certain limit.

Fluids containing a larger amount of salts than the blood, remain unabsorbed, and leave the organism through the rectum; fluids containing a smaller amount of salts than the blood enter

into the circulation, absorb, and remove from the organism, through the urinary channels, all the soluble salts and other substances which do not belong to the constitution of the blood; so that, finally, only those substances remain in the organism which exist in chemical combination with the constituents of the blood, and which, therefore, are incapable of being secreted by the healthy kidneys.

"I have convinced myself, by careful and minute examinations, that urine emitted after drinking a copious amount of water, invariably contains a somewhat larger amount of salts than the water which has been drunk; whilst the amount of phosphates contained in the last emitted portions of the urine is extremely minute, and no longer detectible by the ordinary tests. It is therefore obvious that all the salts, without exception, contained in the urine, are to be considered as accidental constituents of the blood, which are excreted and removed from the organism precisely because they no longer form a part of the normal constitution of the blood. The phosphates emitted with the urine were, previously, constituents of substances which have been decomposed in the vital processes, or they existed as constituents of the blood, but upon its transformation into living tissues they were not admitted into their composition, not being required for their constitution.

"Now, among the products of the vital processes, which, together with the soluble phosphates, are removed from the organism through the urinary organs and channels, there are two organic acids, namely, *uric* acid and *hippuric* acid, both possessing the property of combining with the soda or potash of the alkaline phosphates, and acquiring in the combination a higher degree of solubility than they possess, *per se*, at the common temperature of the body. It is obvious that by the accession of these two acids, and by their action upon the phosphates of soda, an urate and hippurate of soda must be formed on the one hand, and an acid phosphate of soda on the other; and that, consequently, the urine must acquire an acid reaction.

But the presence of these two acids in the urine is not the only cause of its acid nature; there exists another cause which tends powerfully to maintain and increase it.

"According to the preceding remarks we ought to find in

the urine all the soluble salts of the food, as well as a small amount of the phosphate of lime, which is soluble to a certain extent in acid fluids, together with magnesia. The amount of these latter substances will be in proportion to their solubility in acid phosphate of soda. The other insoluble salts of the aliments we ought to find in the fæces. In other words, assuming that the materials composing the aliments become converted into oxygen compounds, that is, are burnt in the organism, we ought to find in the urine, all the soluble salts of their ashes, and in the fæces, all the insoluble salts. Now, upon comparing the constitution of the ashes of the blood or of the aliments, (or, rather, the salts contained therein,) with those of the urine, we find that there exists a striking difference between their respective amount of sulphates.

"According to the analyses of the ashes of the grains of wheat and rye (Ann. der Chemie, vol. 46, p. 79), the urine of an individual feeding exclusively upon bread, ought not to contain a trace of a sulphate, whilst the urine of an animal fed upon peas or beans ought to contain sulphates together with phosphates in the proportion of 9 of the former to 60 of the latter. Finally, as flesh contains no soluble alkaline sulphate (broth does not yield any precipitate of sulphate of baryta when tested with salts of baryta), the urine of carnivorous animals ought to be equally free from soluble sulphates. We find, on the contrary, that the urine of man, according to the most correct analyses, contains a far larger proportion of sulphates than the aliments partaken of; nay, even that the amount of the sulphuric acid evolved from the system must, in many cases, be equal or superior to that of the phosphoric acid contained in the aliments. According to the analyses of human urine made by Berzelius and Lehmann, the amount of the sulphates present in urine is nearly double that of all the soluble phosphates together. Hieronymi found the amount of sulphate of potash contained in the urine of the tiger, the lion, and the leopard, compared with that of the phosphates, to be as 1 to 7½. It can be distinctly and positively proved that these salts have not been partaken of in such proportions. But we now know the origin of the greatest portion of the sulphuric acid contained in the urine; this acid has entered the organism with the food, not in the form of a sulphate, but as sulphur.

"Glutin[1], vegetable casein, flesh, albumen, fibrin, and the cartilages and bones, contain sulphur in a form quite different from the oxygen-compounds of this substance. This sulphur is separated as sulphuretted hydrogen during the putrefaction of these substances; it combines with the alkalies, which act powerfully upon these animal substances, and may be obtained from such combinations in the form of sulphuretted hydrogen by means of stronger acids.

"Now, we know, from the experiments from Wöhler, that the soluble sulphurets become oxidized in the organism; and that thus, for instance, sulphuret of potassium becomes converted into sulphate of potash; and it is therefore unquestionable that the sulphur of the constituents of the blood, derived from the aliments, or, what comes to the same point, the sulphur of the transformed tissues becomes finally converted into sulphuric acid by the oxygen absorbed in the process of respiration, and thus that in the urine it must appear in the form of sulphates; and from this cause the original amount of these salts contained in the aliments become increased. The alkaline base which we find in the urine, in combination with this sulphuric acid, is supplied by the soluble alkaline phosphates; and the latter, in consequence of the loss of part of this base, are converted into acid salts.

"It follows, from all we have hitherto stated, that the acid nature of the urine of carnivorous animals, as well as that of man, depends upon the nature of the bases partaken of in the aliments, and upon the particular form of their combinations. In the flesh, blood, and other parts of animals, as well as in the grains of the cereal and leguminous plants, there exists no free alkali. The alkali which these substances contain is invariably combined with phosphoric acid: the acids formed in the organism by the vital process, namely, sulphuric acid, hippuric acid, and uric acid, share the alkali amongst them, and this, of course, must give rise to the liberation of a certain amount of phosphoric acid, or what comes to the same point, to the formation of a certain amount of acid phosphates of soda, lime, and magnesia. The proportional amount of the liberated phosphoric acid varies with the temperature; at a higher tempera-

[1] Dietrich (in the laboratory of Giessen) has examined glutin with regard to its amount of sulphur; he found wheat-gluten to contain from 0·033 per cent. to 0·035 per cent. of sulphur, exactly the same proportion as is contained in albumen or fibrin.

ture the phosphate of soda dissolves a larger amount of uric acid and hippuric acid than at a lower temperature,—at 100° more than at 60°. It is owing to this, that urine, upon refrigeration, sometimes deposits uric acid, or urate of soda in a crystalline state, which, of course, can only take place by the uric acid, at a lower temperature, restoring to the phosphoric acid the soda or potash which, at a higher temperature, it had withdrawn from it. At the common temperature phosphoric acid decomposes urate of soda, whilst, at a higher temperature, uric acid decomposes phosphate of soda. When urine, containing uric acid and manifesting an acid reaction, forms no sediment upon cooling, it shows that the amount of the phosphoric acid and that of the uric acid exactly balance each other with regard to their affinity for soda. Had there been present a larger proportion of uric acid, this would have separated upon cooling; whilst, on the other hand, the presence of a preponderating proportion of phosphoric acid would likewise have caused the precipitation of uric acid, because the affinity of the former for soda would then exceed that of the latter. This explains the circumstance that urine, in certain states, when, from some cause or other, its amount of sulphuric, hippuric, or other acid, becomes increased, precipitates a larger proportion of uric acid than urine in its normal state. The solubility of uric acid in urine must decrease in proportion as the amount of the other acids present in the urine increases, because those acids share the soda with the uric acid; and, of course, the larger the amount of soda which combines with these other acids the less comes to the share of the uric acid. It is likewise owing to this, that uric acid is very frequently precipitated from urine upon the addition of mineral or other acids, and that urine of a turbid whey-like appearance, from the presence of uric acid, frequently manifests a far more strongly acid reaction than normal urine.

"Now, bearing in mind that the use of alkaline citrate, of neutral tartrate of potash, bi-tartrate of potash, acetates of potash and soda, and tartarized soda, renders the urine alkaline by creating in it an amount of carbonated alkali; and that, likewise, after the eating of fruit, such as cherries, strawberries, &c., the urine is of an alkaline nature, inasmuch as these fruits contain alkalies combined with vegetable acids,

it is obvious that the acid reaction of healthy urine is purely accidental, and that urine of an alkaline or neutral reaction cannot be considered as a symptom of a diseased condition of the body. All the vegetable aliments, without exception, tubers, roots, and leaves, potatoes, turnips, greens, &c., contain alkalies in combination with vegetable acids: potatoes, for instance, contain alkaline citrates; turnips, alkaline racemates and oxalates, &c. All these plants yield, upon incineration, more or less strongly alkaline ashes, the bases of which were contained in the living plants, as salts of vegetable acids.

"It is obvious that by adding these vegetables to a meat diet, to bread and to other aliments prepared from flour, the nature of the urine must become thoroughly altered; for the alkalies which these vegetables contain in combination with organic acids, enter the urine, in the form of carbonated alkalies, and neutralize the acids, of whatever kind, which may be present. When partaken of in a certain proportion, they render the urine neutral; when partaken of in a larger proportion they impart to it an alkaline reaction.

"The urine of all animals feeding upon vegetables, such as grass, herbs, roots, &c., has an alkaline reaction. The urine of the horse, of the cow, of the sheep, of the camel, of the rabbit, of the guinea-pig, of the ass, &c., is alkaline; it contains alkaline carbonates, and acids produce in it a lively effervescence.

"The acid, neutral, or alkaline reaction of urine of healthy individuals does not depend upon any difference in the processes of digestion, respiration, or secretion, in the various classes of animals, but upon the constitution of the aliments, and upon the alkaline bases which enter the organism through the medium of these aliments. If the amount of these bases is sufficiently large to neutralize the acids formed in the organism, or supplied by the aliments, the urine is neutral; whilst it manifests an alkaline reaction when the amount of alkaline bases thus supplied to the organism is more than sufficient to neutralize the acids; but in all these cases the urine accords with the nature of the aliments taken.

"The inorganic bases and acids contained in the urine were, with the exception of sulphuric acid, which joins them in the organism, constituents of the aliments. The amount of inorganic bases and acids emitted through the urine in twenty-four

hours must, in adult individuals, be equal to that of these bases and acids supplied to the organism, during the same period, through the medium of aliments."[1]

Our knowledge respecting the influence of diet on the composition of the urine has been much increased by the admirable researches of Lehmann,[2] instituted on himself. The whole of the urine passed in twenty-four hours was always collected, the absolute weight and specific gravity determined, as well as the amount of solid residue. The investigation was commenced in October, and the amount of drink was only just sufficient to allay thirst. During thirteen successive days, on which he lived on his ordinary mixed diet, the following observations were made:

Amount of urine in 24 hours.	Spec. grav.	Solid residue per mille.	Whole amount of solid residue, in grammes.
1088 grammes[3]	1017·4	58·432	63·5718
898	1022·2	65·998	59·2662
927	1025·1	67·842	62·8895
1022	1024·7	66·744	68·2124
712	1029·2	79·923	56·9052
1361	1020·2	65·008	78·4759
900	1019·2	62·318	56·0862
940	1022·5	66·423	62·4376
1100	1019·1	61·984	68·1824
939	1029·4	80·878	75·9434
1448	1016·7	56·264	81·4702
1088	1025·2	67·981	73·9633
1328	1015·6	55·932	74·2777

A perfect analysis of the urine was made on three of these days, the results of which are recorded in p. 144.

The amount of urea was determined on the 1st, 2d, 4th, 6th, 7th, 8th, 11th, and 12th days. The results are given in the following table:

Solid residue in 1000 parts of urine.	Urea in 1000 parts of urine.	Urea in 100 parts of solid residue.	Daily amount of urea, in grammes.
58·430	26·72	45·74	39·077
65·988	32·91	49·87	29·556
66·744	28·22	43·79	29·869
65·008	29·25	44·99	35·306
62·318	31·45	50·46	28·301
66·423	29·50	44·41	27·728
56·264	23·72	42·15	34·339
67·981	32·91	48·41	35·804

[1] Lancet, June 1844. [2] Journal für praktische Chemie, 1842-3.

[3] The gramme = 15·4 grains troy.

From these data it appears that, during his ordinary mixed diet, the urea amounted on an average to 46·23% of the solid residue, and that the average amount of urea excreted in twenty-four hours was 32·498 grammes, or about 500 grains.

The amount of uric acid was determined on the 2d, 6th, 7th, 8th, 11th, and 12th days. The following results were obtained:

Uric acid in 1000 parts of urine.	Uric acid in 100 parts of solid residue.	Daily amount of uric acid, in grammes.
1·073	1·626	0·967
1·124	1·729	1·357
1·021	1·638	0·919
1·097	1·651	1·031
1·131	2·001	1·630
1·098	1·615	1·195

From these numbers it appears that 1000 parts of urine contain, on an average, 1·089 of uric acid; and that 100 parts of solid residue contain 1·71 of uric acid; likewise, that the daily amount of excreted uric acid is 1·183 gram., or about 18·3 grains. Hence the daily amount of urea is to that of uric acid as 27 : 1.

The mean amount of free lactic acid, (or, at least, the substance regarded by Lehmann as lactic acid,) in 1000 parts of urine was 1·525; and in 100 parts of solid residue, 2·325. The mean daily amount was 1·534 gram., or 23·6 grains.

The mean amount of combined lactic acid in 1000 parts of urine was 1·160; and in 100 parts of solid residue, 1·703. The mean daily amount was 1·173 gram., or 18 grains.

Having thus determined a standard of comparison, he proceeded to notice the effect of a purely animal diet on the urine. He lived for twelve days on a purely animal diet, and for four of these days entirely on eggs, during which period he consumed 128, or 32 a day. From an analysis of the eggs it appeared that he took daily 189·7 grammes of dry albumen, free from ash, and 157·48 grammes of fat; and from Scherer's analyses it appears that this albumen contained 104·335 grammes of carbon, and 30·16 grammes of nitrogen; while the fat contained 124·41 grammes of carbon. Hence the whole amount of carbon was 228·75 grammes, a little within the amount given off in the course of twenty-four hours, according to Liebig. The observations were conducted for twelve successive days in July, and yielded the following results:

Absolute weight of urine in 24 hours, in grammes.	Spec. grav.	Solid residue in 1000 parts.	Whole amount of solid residue, in grammes.
921	1029·2	80·87	79·34
1240	1021·9	66·12	81·99
998	1030·7	84·23	84·06
1075	1027·8	77·72	83·55
1184	1026·4	72·30	85·61
1384	1018·7	59·21	82·09
1113	1028·5	78·15	86·99
1092	1028·9	79·04	86·23
979	1033·8	90·68	88·78
1211	1026·3	72·38	87·85
1346	1024·3	66·73	89·84
1127	1029·0	78·38	88·38

If we compare the mean of these numbers with the mean of the former corresponding table, we have:

	During a mixed diet.	During animal diet.
The absolute weight of the urine in 24 hours . . .	1057·8 grammes	1202·5 grammes
Specific gravity . . .	1022·0	1027·1
Amount of solid residue in 1000 parts of urine . . .	65·82	75·48
Sum of the solid constituents .	67·82 grammes	87·44 grammes

Hence it appears that, during a purely animal diet, the amount of solid constituents is increased, while at the same time the amount of water is augmented by no less than 125 grammes, notwithstanding these experiments were made in June, and those with a mixed diet in October.

From the above data it appears that the solid matters discharged by the urine during an animal diet amount to about one fourth of the amount of dry nutriment.

The following are the principal changes in the urine induced by use of a strictly animal diet. It becomes pale, of a straw colour, limpid, and similar in appearance to the urine of the carnivora. On the addition of nitric acid, crystals of nitrate of urea were immediately produced. Uric acid was gradually deposited in large crystals. The reaction of the urine was always decidedly acid. Two analyses instituted with the urine passed on the 28th and 30th of July, (the 9th and 11th days of the experiment,) gave the following results:

	July 28th.	July 30th.
Water	909·32	933·27
Solid residue	96·68	66·73
Urea	53·79	41·65
Uric acid	1·41	1·18
Free lactic acid	2·28	1·64
Lactates	1·67	1·02
Extractive matter soluble in water	0·82	0·61
Extractive matter soluble in alcohol	4·50	3·24
Mucus	0·09	0·11
Chlorides of sodium and ammonium	5·37	3·46
Sulphates	11·51	7·08
Phosphate of soda	5·52	4·04
Earthy phosphates	3·72	2·70

The six following observations were made regarding the amount of urea:

	Urea in 1000 parts of urine.	Urea in 100 parts of solid residue.	Urea secreted in 24 hours, in grammes.
July 23d (the 4th day of the experiment)	45·71	58·815	49·134
27th	46·67	59·043	50·913
28th	53·79	59·320	52·034
29th	46·19	63·811	56·095
30th	41·65	62·413	54·071
31st	50·36	64·382	56·887

From these numbers it appears that, during a purely animal diet, there is a mean daily increase of 20·7 grammes in the amount of urea. During a mixed diet, the relation of the urea to the other solid constituents = 100 : 116, while on an animal diet it = 100 : 63. The uric acid was estimated on the last four days of the experiment:

	Uric acid in 1000 parts of urine.	Uric acid in 100 parts of solid residue.	Daily amount of uric acid, in grammes.
28th July	1·41	1·554	1·371
29th	1·20	1·630	1·432
30th	1·18	1·764	1·565
31st	1·37	1·749	1·546

Hence, while the mean daily amount of uric acid during a mixed diet is 1·183 grammes, the amount is increased during an egg-diet by ·295 of a gramme, an increase not sufficiently large to entitle us to suppose that a purely animal diet favours the formation of uric acid in the healthy organism. During a mixed diet, the proportion of uric acid to the other solid con-

stituents = 1 : 58·5, during an animal diet it = 1 : 59·7; i.e. there is a relative diminution. The proportion of uric acid to urea during a mixed diet = 1 : 27·0, during an animal diet it = 1 : 32·7; consequently the uric acid is not by any means increased in the same proportion as the urea; and, indeed, it can hardly be regarded as produced from the protein-compounds in the same manner as the urea probably is.

The mean amount of free lactic acid excreted daily (as deduced from four analyses) was 2·167 grammes.

The earthy phosphates were determined daily from the 27th till the 31st of July, when the experiments were discontinued. The following are the results obtained:

In 1000 parts of urine, in grammes.	In 100 parts of solid residue.	Daily amount, in grammes.
3·09	3·913	3·374
3·72	4·102	3·642
2·99	4·134	3·632
2·70	4·046	3·635
3·13	3·994	3·530

Consequently, during a purely animal diet, 3·562 grammes of earthy phosphates are, on an average, discharged daily by the urine; while, during a mixed diet, the average quantity is only 1·13 grammes. If we estimate the amount of earthy phosphates in the albumen at 2%, the whole quantity consumed daily with 189·7 grammes of albumen, amounts to 3·794 grammes; consequently, much the greater part (namely, 3·562 grammes) is carried off by the urine, while the remaining ·232 of a gramme is removed with the excrements, perspiration, &c.

During a mixed diet, a much larger amount of earthy phosphates was consumed without there being a corresponding increase in the urine, the greater part being removed by the intestinal canal. Generally speaking, the amount of excreted earthy phosphates exceeds the amount consumed, the excess, doubtless, arising from the oxidation of the phosphorus contained in the protein-compounds during the metamorphosis of the tissues. This view is confirmed by the preceding observations; for, during the egg-diet, the phosphorized fat contained in the oil of the yelk is conveyed into the fluids of the body, and, by the oxidation of its phosphorus, in addition to the phosphorus of the protein-compounds, the phosphoric acid of

the phosphate of lime is generated, while only a portion of the earthy phosphates of the food is conveyed into the blood. Lime occurs in the blood in considerable quantity, being conveyed there by the water taken as drink, and combining readily with the free phosphoric acid. Moreover, a further confirmation of this view is afforded by the fact of the increased excretion of phosphate of soda. During a mixed diet, the daily average is 3·673 grammes, while, during a purely animal diet, it amounts to about 5·217 grammes.

Lehmann next proceeded to investigate the effects of a strictly vegetable diet. The urine was examined daily from the 12th to the 23d of August; it was of a yellowish-brown rather than a yellow colour; it had a faint odour, and a decidedly acid reaction, which did not disappear for six or eight days. The morning urine was of a dark brown colour, and rapidly deposited a mucous sediment, after which there was a gradual separation of bright red crystals of uric acid. The following table contains the daily amount of urine and of its solid constituents, and the specific gravity:

Absolute weight of urine in 24 hours, in grammes.	Spec. grav.	Solid residue in 1000 parts.	Daily amount of solid residue, in grammes.
980	1028·9	67·60	66·25
765	1036·1	82·76	63·31
1059	1020·1	55·85	59·14
978	1025·7	60·13	58·81
1212	1016·4	50·01	60·61
817	1032·3	75·68	61·83
916	1026·8	63·09	57·79
720	1034·2	80·76	58·15
796	1029·8	70·90	56·44
931	1023·8	58·09	54·08
811	1028·6	67·01	56·35
892	1027·9	65·08	58·05

By taking the mean of these numbers we are enabled to construct the following table:

	On mixed diet.	On animal food.	On vegetable food.
Amount of urine in 24 hours .	1057·8 gr.	1202·5 gr.	909 gr.
Specific gravity . .	1022·0	1027·1	1027·5
Solid residue in 1000 parts of urine . . .	65·82	75·48	66·41
Solid constituents in 24 hours .	67·82 gr.	87·44 gr.	59·23 gr.

The amount of urea was ascertained daily from the 17th to the 23d of August:

Urea in 1000 parts of urine.	Urea in 100 parts of solid residue.	Daily amount of urea, in grammes.
28·87	38·145	23·585
26·00	41·211	23·815
30·68	37·988	22·089
28·31	40·078	22·618
22·42	38·607	20·880
25·52	33·093	21·467
25·69	39·478	22·917

Hence, on an average, the urea amounted to 39·086% of the solid residue, and 22·481 grammes were daily excreted. The effect of diet on the urea may be seen by the following table:

	In 100 parts of solid residue.	Daily amount, in grammes.
Urea during a mixed diet . .	46·230	32·498
„ an animal diet . .	61·297	53·198
„ a vegetable diet . .	39·086	22·481

Consequently, during a vegetable diet, there is both an absolute and a relative diminution of urea.

The uric acid was determined on five occasions:

Uric acid in 1000 parts of urine.	Uric acid in 100 parts of solid residue.	Daily amount of uric acid, in grammes.
1·40	1·836	1·135
1·23	1·947	1·125
1·17	1·652	·933
1·01	1·743	·942
·89	1·489	·969

Consequently, the average daily amount (from these five analyses) was 1·021 grammes; and, on comparing this with the previous data, we have:

	In 100 parts of solid residue.	Daily amount, in grammes.
Uric acid during a mixed diet . .	1·710	1·183
„ an animal diet . .	1·674	1·478
„ a vegetable diet .	1·737	1·021

Hence the uric acid is scarcely affected by the diet.

From three analyses it appeared that 1·189 grammes of free, and 1·371 grammes of combined lactic acid were daily excreted during a vegetable diet; and, associating these with the previous numbers, we have:

	During a mixed diet.	During an animal diet.	During a vegetable diet.
Free lactic acid .	1·462	2·167	1·189 grammes
Combined lactic acid .	1·162	?	1·371

Hence there is not any very appreciable effect produced on the amount of the lactic acid. The phosphates and sulphates were much the same as during a mixed diet.

The three following perfect analyses of the urine were instituted:

	Aug. 20th (the 9th day of the experiment.)	Aug. 21st.	Aug. 23d.
Water . . .	929·10	941·91	934·92
Solid residue . .	70·90	58·09	65·08
Urea . .	23·31	22·42	25·69
Uric acid . .	1·17	1·01	0·89
Lactic acid . .	1·55	1·01	1·35
Lactates . .	2·39	1·89	2·06
Extractive matter soluble in water	3·80	3·07	3·71
" " alcohol	17·84	13·78	15·77
Mucus . .	·12	·10	·10
Chlorides of sodium and ammonium	3·80	3·07	3·71
Sulphates . .	7·16	7·14	7·23
Phosphate of soda .	3·54	3·68	3·74
Earthy phosphates .	1·22	1·09	1·11

The following table shows how much the extractive matters are influenced by diet:

	Extractive matters in 100 parts of solid residue.	Extractive matters discharged daily.
During a mixed diet . .	16·637	10·489 grammes
" an animal diet . .	5·818	5·196
" a vegetable diet . .	29·482	16·499

Lehmann concluded his experiments with some observations on the influence of a strictly non-nitrogenous diet on the urine. These are the least satisfactory of the series, because the general health becomes so rapidly injured as to affect the results. His daily food consisted of about 400 grammes of starch, sugar, or gum, and 125 grammes of almond oil. The urine passed after this diet had been continued for twenty-four hours had a brownish red colour, a slightly acid reaction, and became alkaline in twenty-four to thirty-six hours. The following analyses were made in the month of June, on the 2d and 3d day from the commencement of this course of diet:

	1.	2.
Water	953·98	965·11
Solid constituents	46·02	34·89
Urea	18·92	11·08
Uric acid	·89	·54
Lactic acid and lactates	4·89	5·11
Extractive matter soluble in water	2·80	2·71
" " alcohol	8·32	8·78
Mucus	·11	·11
Chlorides of sodium and ammonium	2·74	1·14
Sulphates	3·25	2·98
Phosphate of soda	3·01	2·48
Earthy phosphates	1·00	·91

On the second day 977 grammes, and on the third 1113 grammes of urine were discharged, so that the whole amount was calculated as follows:

	On the 2d day.	On the 3d day.
Solid constituents	44·524 grammes	38·836 grammes
Urea	18·484	12·332
Uric acid	·869	·601
Lactates	4·865	5·687
Extractive matters	10·864	12·844

In conclusion, the following table gives the mean daily amount of the various solid constituents during these different systems of diet:

	Mixed diet.	Animal diet.	Vegetable diet.	Non-nitrogenous diet.
Solid constituents	67·82	87·44	59·24	41·68 grammes
Urea	32·50	53·20	22·48	15·41
Uric acid	1·18	1·48	1·02	·73
Lactic acid and lactates	2·72	2·17	2·68	5·82
Extractive matters	10·49	5·20	16·50	11·85

Lehmann[1] has likewise examined the effect of severe bodily exercise on the urine, and has found that the urea, lactic acid, phosphates, and sulphates are increased, while the uric acid and extractive matters are diminished. The following are the mean results obtained from the frequent examination of the daily urine during a pedestrian tour:

	In 24 hours.	In 1000 parts.
Water	900·006 grammes	916·707
Solid constituents	82·594	83·293
Urea	45·314	45·697
Uric acid	·642	·647
Lactic acid	3·140	3·166
Extractive matters	8·455	8·526
Alkaline phosphates	4·598	4·636
Alkaline sulphates	15·047	15·174
Earthy phosphates	1·105	1·114]

[1] Wagner's Handwörterbuch der Physiologie: Art. Harn. vol. 2, p. 21.

The admirable researches of Lecanu[1] show that the urine of the same person, analysed at different times, gives nearly uniform results.

The urine of persons of different ages and sexes exhibits deviations both in the relative and absolute proportion of its constituents, while in persons of similar ages and sexes, the variations are very trifling.

The quantity of urine discharged by different persons, in the course of the twenty-four hours, varies considerably, even although the circumstances under which the observations are made are apparently similar. In 16 individuals of different ages and sex, with different but sufficient food, the quantity varied from 18 to 78 ounces.

The mean specific gravity of the urine of different persons varies. The highest specific gravity was 1030, the lowest 1016. It was most frequently between 1020 and 1030. The urine of men in the prime of life was more concentrated than that of old men, women, or children.

The quantity of urea amounts, according to Berzelius and Lehmann, to nearly one half of the solid constituents; according to my observations, to a little more than a third. It follows, from the experiments of Lehmann, which have just been stated, that these proportions are dependent on the nature of the food; it is certain, however, that they are also dependent on the powers of assimilation, for we know that some persons thrive upon a very frugal, and barely sufficient diet; while others appear half-starved, although taking an abundance of nutritious food.

According to Lecanu, the quantity of urea which different individuals, living under different circumstances, secrete during the same period, differs greatly; it approximates, however, in proportion to the similarity of the circumstances.

In the course of twelve days there was secreted by—

A man aged	20 years,	334 grammes of urea
	22	334
	38	310
	43	351
	53	364
A woman aged	28	205
	16	210
A child aged	8	171
	8	168

[1] Journal de Pharmacie, vol. 35, 1839.

The quantity of urea is greatest in men in the prime of life; it is greater in women than in old men, or children. It amounts in—

	Mean.	Maximum.	Minimum.
Men	432	509	357 grains
Women	294	436	153
Old men	125	189	60
Children aged 8	207	253	161
„ 4	69	82	57

The quantity of urea excreted by the same individual in twenty-four hours, is always nearly the same; and if instead of twenty four hours, we compare it for a longer period, the deviation will be still less marked.

The quantity of uric acid excreted in twenty-four hours by persons of different age and sex, and living under different circumstances, is as variable as the quantity of urea. It fluctuated between 1·38, and 24·25 grains. A comparison of the quantities of uric acid excreted during a longer period by persons of the same age, sex, &c. will show that they nearly coincide.

In twelve days there were excreted by—

A man aged	20 years,	11·945 grammes of uric acid
	22	11·967
	38	13·434

In eight days there were excreted by—

A girl aged	19 years,	3·778 grammes of uric acid
A woman aged	43	3·619

The quantity of uric acid excreted by the same person during the same period (a period of some days for instance) is always nearly constant. This observation is confirmed by the analyses of Lehmann, and myself.

The amount of fixed salts, (earthy phosphates, chloride of sodium, alkaline sulphates and phosphates,) excreted in twenty-four hours, varies considerably with age and sex. It fluctuated (in Lecanu's analyses) between 378 and 75 grains. There was apparently no uniformity in the amount of these salts in the urine of the same person during different equal periods. For instance, in a man aged 20, the amount of fixed salts in the urine of twenty-four hours, was determined four times. It varied from 348 to 224 grains.

In men, in the prime of life, the amount of fixed salts is higher than in aged persons, children, or women.

They occur, according to Lecanu, in the following proportions:

	Mean.	Maximum.	Minimum.
In Men . . .	260	378	153 grains
Women . .	222	302	166
Children of about 8 years .	135	168	152
Old men . .	124	151	94

Lecanu found the earthy phosphates in the urine of twenty-four hours vary in different persons from 30·3 grains to rather less than half a grain.

The amount of earthy phosphates, excreted in twenty-four hours by the same person, is not always uniform; it appears to have no direct connexion with either age or sex.

In accordance with Guibourt and Rayer, Lecanu found these salts in smaller quantity in the urine of old men than in that of children. From the analyses made by Lecanu, Lehmann, and myself, it appears that the variations in the amount of the earthy phosphates, both absolutely and relatively, are less than those of the other constituents of the urine.

A considerable difference was observed by Lecanu in the amount of chloride of sodium excreted by different persons. In his analyses the quantity excreted in twenty-four hours fluctuated between 116 grains and a quarter of a grain. Moreover, the quantity excreted by the same person in twenty-four hours is by no means constant. In four observations, each made on the urine of twenty-four hours, of a man aged 20, the maximum was 116, and the minimum 67 grains: in six similar observations on the urine of a man aged 35 years, the maximum was 82, and the minimum 29 grains. Lecanu found the quantity of chloride of sodium very small in the urine of women and old men.

It is clear that the excretion of a salt taken with most of our articles of food, must be entirely dependent on the quantity consumed, and must therefore vary very considerably. The urine, generally speaking, is deficient in salts during disease: our analyses show that the deficiency occurs at the expense of the chloride of sodium; the sulphates and phosphates taking only a small part in it. I have analysed urine in typhus which contained a mere trace of chloride of sodium.

Lecanu observed differences similar to those we have just

noticed in the alkaline sulphates and phosphates. The quantities excreted in twenty-four hours not only varied in different persons, but also in the same persons at different times. From my analyses, and those of Lehmann, it appears probable that a connexion subsists between the quantity of urea and of the sulphates, and possibly of the phosphates likewise; that is to say, the sulphates always increase with the urea, and *vice versâ*. I incline, therefore, to the opinion of Berzelius, that at least a portion of the sulphates and phosphates owe their origin to the oxidation of sulphur and phosphorus, previously associated with protein which has become changed during the active metamorphosis of the blood. We do not, however, mean, in making this statement, to deny that the salts are also supplied to the blood by the food, and again separated by the kidneys.

The five following results, of much importance in physiology, have been deduced from the admirable researches of Lecanu:

1. The quantity of urea excreted by the same person during equal periods is constant.
2. The same is the case with respect to the uric acid.
3. The quantities of urea and uric acid excreted by different persons during equal periods are variable.
4. The varying amounts of urea excreted during equal periods by different persons, bear a relation to age and sex.
5. The amount of fixed salts varies in different persons without reference to age or sex. It also varies in the same person during equal periods.

An observation simultaneously made by Lehmann[1] and myself,[2] appears to me of high physiological import. We have ascertained that the amount of the urea, as well as of the sulphates, is increased by strong bodily exercise. I produced this state by taking such violent exercise for two hours that the pulse continued for some time above 100.

Further confirmation of the above observation is certainly desirable.

If, however, we might assume it as a general fact, it would be an additional argument in favour of my view regarding the formation of urea; for it would then become still clearer that the urea is not formed during the change which occurs in the

[1] See page 164. [2] See page 144.

blood as a consequence of peripheral nutrition, but that it is formed during those processes which are dependent on the respiratory and circulatory functions, in which we must seek for the greater part of the carbonic acid which is exhaled, and for the principal source of animal heat. I refer to the active metamorphosis of the blood, or to the mutual action excited by the blood-corpuscles, the plasma, and the oxygen held in solution in the blood, on each other.

[I am indebted to the kindness of Dr. Percy for the following analyses, which, to a certain amount, corroborate Simon's views.

The urine of a man, aged 30 years, training for a pedestrian match, was examined on two occasions: on the first, a quarter of an hour after running a mile in five minutes and a few seconds; on the second, after running three races of one mile each on the same day.

In both cases the urine was of a pale straw colour; it deposited a slight mucous cloud on the first occasion, and was rather more turbid on the second. It was acid, and its specific gravity was 1019. It contained in 1000 parts:

	1.	2.
Water	956·00	950·80
Solid constituents	44·00	49·20
Urea	14·01	20·42
Uric acid	1·58	·64
Salts soluble in water	11·16	7·88
Salts insoluble in water	1·10	1·48

Although the soluble salts are not increased as in the cases of Lehmann and Simon, the augmentation of urea is very striking.]

To sum up once more: the urine is most abundant in urea, uric acid, and the most important salts, in men in the prime of life; it is less rich in these constituents in women; while the minimum occurs in old men and children. The nature of the food exerts an influence upon the composition of the urine: the amount of urea is increased by an excess of nitrogenous food, and diminished after living on food deficient in nitrogen. Upon a diminution of the quantity of food, the urine becomes deficient in nitrogen, as has been shown by my own experi-

ments[1] and those of Lehmann, but the separation of nitrogenous compounds, as for instance urea, through the urine, occurs even when no food is taken. The urine is most abundant in urea and sulphates after active bodily exercise, in consequence, doubtless, of increased vascular excitement. The quantity of urine discharged in twenty-four hours, amounts on an average to about 45 ounces. It is more abundant in the prime of life than in old age or childhood, and in the male than in the female sex.

ON PATHOLOGICAL CHANGES IN THE URINE.

During disease the urine may undergo numerous modifications, both in its physical characters and its chemical constitution. The chemical changes may be reduced to one of the following forms.

1. One or more of the normal constituents of the urine existing in larger quantity than in healthy urine.
2. One or more of the normal constituents existing in less quantity than in healthy urine.
3. A normal constituent absent.
4. The presence of substances that do not exist in normal urine.

Qualitative and quantitative analyses of urine modified by disease.

In tracing the changes which the urine undergoes in disease, the simple addition of certain tests is sometimes all that is sufficient, while in other cases it is requisite to institute a quantitative analysis. I shall now proceed to describe these changes in accordance with the above scheme.

INCREASE, DECREASE, OR ABSENCE OF THE NORMAL CONSTITUENTS OF THE URINE.

1. *Increase or diminution of the solid constituents generally.*

I have already observed that the proportion of the solid constituents to the water is so very variable, is so dependent upon the vicarious action of the skin and lungs, and upon the quan-

[1] Brande's Archiv, xxii, p, 25.

tity of fluid that has been taken into the system, that it is impossible (without taking other facts into consideration) to determine from the urine alone, whether a mere increase or decrease of the solid constituents is due to diseased action. Pale urine, more or less like water, may be fairly considered deficient in solid matters, while a deep brown colour is indicative of an abundance of these constituents.

The specific gravity,[1] and still more the determination of the solid constituents in the manner which has been already described, will give the required information. The colour of the urine is sometimes deceptive, especially the fiery red that occurs during fevers. Urine of this sort is frequently found to be poorer in solid constituents, and its specific gravity lower than we should have anticipated from its colour: it is usually, however, more abundant in uric acid than normal urine.

2. *Increase or decrease of free lactic acid.*

With a little practice we may form a rough estimate of the increase of free acid, by observing the colour which the urine imparts to blue litmus paper. If neither the blue nor the red litmus paper is affected the urine is neutral.

3. *Increase, decrease, or absence of urea.*

In the course of my analyses, I have found that the quantity of urea may vary from 0·3% to 2·4% in fresh urine; I have observed, however, at the same time, that these statements are very deceptive, if the amount of solid residue is not at the same time given. It is only by comparing it with the solid residue that we can judge whether the urea has increased or decreased in an extraordinary manner. In healthy urine the urea may probably fluctuate from $\frac{1}{3}$ to $\frac{1}{2}$ of the weight of the solid constituents. Further experience is wanted to show whether an increase or decrease of this constituent (apart from other changes) implies a diseased state of the urine.

Urine has been known to yield crystals of nitrate of urea,

[1] The common urinometer is sufficiently accurate for ordinary cases.

a short time after the addition of nitric acid, without being first concentrated by evaporation. Indeed Lehmann observed that his morning urine, after living exclusively for five days on animal food, contained so much urea, as to stiffen immediately upon the addition of nitric acid. This might arise either from an absolute increase of urea, or from a relative increase, corresponding with an augmentation of the solid constituents generally.

An entire absence of urea has been observed in cases of diabetes insipidus, in which the urine is distinguished by an extreme deficiency of solid constituents: such statements should, however, be received with caution. Willis[1] instances such cases; he is, however, inclined to believe that it is always present in very small quantity. In order, therefore, to offer a decided opinion regarding either the absolute pathological increase or decrease of urea, it is requisite to estimate its weight, and the ratio of its weight to that of the solid constituents generally. The method of determining the urea is described at page 136. If the quantity of urea is so small as to render the crystallization of its nitrate imperceptible to the naked eye, the microscope must be used in the manner described when treating of the Blood, in Vol. I, page 182.

4. *Increase, decrease, or absence of uric acid and the urates.*

The variation in the quantity of uric acid in diseases has long been known, but it has not yet been determined with certainty whether this is in all cases an absolute, or whether in some cases it is merely a relative increase dependent upon the increased amount of solid constituents generally. The point must be determined by the quantitative analysis of uric acid, and its ratio to the solid constituents generally.

a. Increase of uric acid. Urine, containing an excessive quantity of uric acid, exhibits in most cases a very high colour, and has an acid reaction. Its specific gravity is frequently lower than would have been supposed from the intense colour.

[1] Urinary Diseases and their Treatment. By Robert Willis, M.D. p. 37.

If this urine is allowed to stand for some hours, there are deposited, partly at the bottom, and partly on the sides of the vessel, (and they are not unfrequently observed on the surface,) small crystals perceptible to the naked eye, whose form, under the microscope, usually appears as delineated in fig. 23*a*, sometimes as in fig. 23*b*. Vigla[1] states, that in addition to the crystallized uric acid, a portion separates as an amorphous powder. It is only rarely that I have observed uric acid deposited in this amorphous form: the amorphous sediment of a yellow or reddish colour, which frequently occurs in large quantity in acid urine, may be shown to consist of urate of ammonia, by its ready solubility when the urine is warmed. Rayer, in his work on Diseases of the Kidneys, describes the crystalline form of uric acid, which is represented in fig. 23*c*.

As a further evidence that these crystals are composed of uric acid, they may be tested with nitric acid in the manner explained in page 116.

A brown or reddish-brown sediment is sometimes observed to be deposited in dark reddish-brown urine, which does not disappear either upon the application of heat or the addition of hydrochloric acid, and in fact in the latter case is rather increased. Under the microscope it exhibits the described forms of uric acid. We also observe, although more rarely, that dark urine will deposit a dense gray or yellow granular sediment, which is shown, by the application of heat, by the addition of hydrochloric acid, and by the microscope, to consist also of uric acid coloured by a peculiarly small quantity of uroerythrin. If the amount of uric acid is to be determined quantitatively in these instances, we must have regard not merely to the uric acid which is deposited, but also to that which remains in solution. The amount of the whole urine is determined as accurately as possible, the sedimentary uric acid collected on a weighed filter, washed with distilled water, dried, and weighed. Any uric acid that adheres to the glass, and cannot be removed by a feather or a glass rod, or by washing out the glass with water, must be treated with some warm solution of potash, until it is dissolved.

[1] Etude microscopique de l'urine, eclarée par l'analyse chymique. (L'Expérience, vol. 1, p. 193.)

The alkaline solution must be filtered, and the uric acid precipitated by hydrochloric acid, collected on a filter, dried, and its weight ascertained. We thus estimate the ratio of the separated uric acid to the whole fluid and to the solid residue, if indeed this element has been determined from a weighed quantity of the urine. A certain quantity of the urine is treated with hydrochloric acid in the manner indicated in page 137, allowed to rest for twenty-four to forty-eight hours, and the precipitated uric acid collected on a filter and weighed. We thus obtain the amount of uric acid held in solution, and its ratio both to the whole amount of urine, and to the solid residue.

b. Increase of urate of ammonia. Urate of ammonia, which, as we have already mentioned in page 115, is probably an invariable constituent of urine, is occasionally excreted to a very large amount during the exacerbations of fever, arthritic attacks and various other diseases. It is the most common form of urinary deposit, but seldom occurs alone; it is frequently mixed with uric acid, sometimes with urate of soda or of lime, and occasionally, but not often, with earthy phosphates. Urine depositing urate of ammonia is generally of dark colour, is seldom clear, and usually exhibits an acid reaction; it is, however, occasionally neutral or even alkaline. It is only in the latter case that earthy phosphates can be present, as they are never precipitated in urine with a marked acid reaction. The colour of urate-of-ammonia sediments varies from a yellowish to a brick-red tint. The red sediments frequently contain free uric acid, and sometimes urate of soda: nearly white sediments of urate of ammonia have occasionally been observed. Urate of ammonia seems to preponderate in the yellow and yellowish-red sediments, and free uric acid in those of a more purple-red colour.

All these sediments may contain more or less mucus.

1. If the sediment consists of urate of ammonia alone, it may be at once recognized by its perfect solution when the fluid is raised to incipient ebullition. To determine this point, the clear fluid is poured from the sediment, some of which is placed in a test tube and heated over the flame of a spirit-lamp: the fluid first becomes transparent on the surface, and gradually

clears throughout its whole extent: on being allowed to cool it again becomes turbid, and deposits the sediment afresh. If a portion of the sediment, after being washed, is rubbed with caustic lime, a perceptible odour of ammonia is developed: and if a few drops of nitric acid are poured over it in a porcelain basin, and gentle heat applied, the purple colour, indicating the presence of uric acid, appears. On heating a little of it on platinum foil, it burns away without a residue.

2. If uric acid is mixed with the urate of ammonia, the sediment sinks rapidly to the bottom, as a dense granular powder, after the fluid has been cleared by the application of heat. If hydrochloric acid is added, after the urate of ammonia has been dissolved by heat, the precipitate on cooling consists of uric acid alone.

3. If earthy phosphates are mixed with the urate of ammonia, the urine is either neutral or alkaline, and is only partially cleared by heat. The turbidity which remains, produced by the earthy phosphates in suspension, disappears immediately upon the addition of hydrochloric acid. Free uric acid is precipitated on cooling.

4. If mucus or pus is mixed with the urate of ammonia the fluid becomes only partially cleared on warming, neither does it become perfectly clear on the addition of hydrochloric acid, since mucus and pus are not dissolved by that agent. If there should be so large a proportion of mucus and earthy phosphates mixed with the urate of ammonia, that the solution of the latter salt on the application of heat produces no perceptible effect, it will only be necessary to filter the heated urine, and to allow it to cool. The separation of urate of ammonia on cooling renders it turbid, and crystals of uric acid may be obtained on the addition of hydrochloric acid.

5. If urine containing urate of ammonia is albuminous, it is necessary to be very cautious in the application of heat as a test. On gently warming the tube, the urate of ammonia dissolves before the albumen begins to coagulate. If the fluid which has thus become clear is exposed to a stronger heat, it becomes cloudy, the turbidity commencing in the upper, hottest stratum of fluid, and gradually extending itself.

Urate of ammonia is recognized under the microscope as an

amorphous mass, in which large, well-defined globules, sometimes united two and two, are often observed. Fig. 28 *a* and *b* exhibit these forms. It is obvious from a comparison of fig. 28 *a*, and fig. 26, that the urate of ammonia, in consequence of its form, may easily be mistaken for phosphate of lime. The following points enable us to distinguish them. Phosphate of lime occurs as a sediment only in neutral and alkaline, never in acid urine. Phosphate of lime when examined under the microscope disappears instantaneously on the addition of a little hydrochloric acid, which usually develops numerous air-bubbles. The sediment of urate of ammonia does not disappear so rapidly under similar treatment, and in a short time, frequently only a few minutes, its place is occupied by rhombic crystals of uric acid, as shown in fig. 28 *c*.

The quantitative determination of urate of ammonia presents no difficulty when no other constituent is present in the sediment. The weight of the urine and the amount of solid residue are accurately determined: the sediment is collected in a filter of known weight, washed with a little ice-cold water, dried, and weighed. The ratios of the amount of sediment to that of the whole urine, and to that of the solid residue are thus obtained. In order to separate the urate of ammonia from uric acid, earthy phosphates, or mucus, with which it may be mixed, the sediment must be collected, and the quantity of urine from which it was deposited, carefully ascertained. The sediment must then be placed in a test-tube with a little of the urine, and gradually raised to the boiling point (if we are previously assured that no albumen is present): it must then be filtered, and the residue washed with a little hot water, while the clear fluid that passes through the filter must be artificially cooled, and the urate of ammonia allowed to separate. It must be collected on a filter, dried, weighed, and its ratio determined in reference to the urine, and to the solid residue. The determination of the urate of ammonia as uric acid, from which the amount of the salt might be calculated would, perhaps, give safer results, since uric acid is less soluble than urate of ammonia.

The fluid which, by the application of heat, has taken up the urate of ammonia from the mixed sediment, must be concentrated by evaporation, and treated while still warm with hydro-

chloric acid. Upon cooling, the uric acid will separate and must be collected.

c. Increase of urate of soda. I am not certain whether urate of soda exists in normal urine. I shall, however, proceed to state in what manner its presence may be recognized in certain pathological conditions. Deposits of urate of soda alone are not often to be met with; this substance is, however, frequently associated with uric-acid and urate-of-ammonia sediments. Urate of soda is detected chemically in the same manner as urate of ammonia; like that salt it dissolves on the application of heat; and when warmed on a porcelain capsule with a little nitric acid, it develops the same purple colour. It differs, however, from that salt, in not developing an odour of ammonia when rubbed with caustic potash, and in leaving a white adhesive residue, when heated on platinum foil. This residue when moistened with water, colours red litmus paper blue, and froths when treated with hydrochloric acid,—(carbonate of soda.) It may be distinguished in the same manner as the urate of ammonia from uric acid, earthy phosphates, mucus, or pus.

Under the microscope it presents the form of globules, mingled with small prisms arranged in stellar groups: at least it is in this form that I have always seen it when obtained artificially; and I have detected such globules, only of a more opaque appearance, in certain urinary sediments. These forms are exhibited in fig. 29 *a* and *b*. Certain forms described by Vigla and Quevenne are given in fig. 29 *c*. This peculiar crystalline arrangement is sufficiently characteristic to enable the urate of soda to be detected when mixed with urate of ammonia, or other sedimentary matters, either crystalline or amorphous.

For a quantitative analysis of a sediment consisting of pure unmixed urate of soda we must proceed in exactly the same manner as for urate of ammonia. If, however, it is mixed with uric acid, earthy phosphates, or mucus, the same method must be adopted as for urate of ammonia under similar circumstances. If urate of ammonia is mixed with urate of soda, they are both held in solution when the urine is warmed, and are thus separated from the other constituents of the sediment.

The solution is then slightly concentrated by evaporation, and afterwards thoroughly cooled. The alkaline urates separate them-

selves, are collected on a filter, dried, and weighed. If the filter with its contents is then incinerated in a platinum crucible, the urate of soda will leave carbonate of soda, which must be converted into a sulphate, and determined in that form. From the sulphate of soda we can reckon the urate, and by deducting the latter from the whole amount of alkaline urates, we obtain the amount of urate of ammonia.

d. Decrease of uric acid. A relative and an absolute decrease of uric acid has frequently been observed. In diabetes mellitus I have sometimes been unable to obtain any trace of it, while in other cases I have found it. If the method described in page 116 fails in yielding any traces of uric acid we are not justified in assuming its entire absence. In doubtful cases we must evaporate a large quantity of urine, and treat the residue with alcohol. The portion of the residue which is insoluble in alcohol must be dissolved in acidulated water, and there is then an insoluble residue left, consisting of mucus, silica, and uric acid (if this constituent be present.) If the nitric-acid test be then carefully applied, we may convince ourselves with certainty whether there is an entire absence of uric acid.

5. *Increase or diminution of the extractive matters and ammonia-compounds.*

An increase or diminution in the quantity of the extractive matters,[1] of the chloride of ammonium, and lactate of ammonia,

[1] [At the meeting of the German Association of Natural Philosophers, held at Nuremberg last September, a paper was read by Scherer, on the extractive matters of the urine. The following are the principal facts he has ascertained. The greater portion of the extractive matters is merely a pigment analogous to those of the blood and bile. It may be thrown down from the urine by acetate of lead, and by treating the precipitate with alcohol and hydrochloric acid, it may be obtained in a state of purity. In healthy individuals it yields from 62 to 63 per cent. of carbon, and from 6·2 to 6·4 of hydrogen. In fevers, when there is rapid waste of tissue, and the functions of the lungs and liver are inactive, the carbon may amount to 66 or 67, and the hydrogen to 7·2 per cent. An increase in the quantity of extractive or colouring matter may be detected by boiling urine in a test-tube, and adding a little hydrochloric acid to it. Urine containing an excess of this colouring matter becomes of a dark colour, and on cooling deposits a brownish, blackish, or frequently an indigo-blue sediment, freely soluble in alcohol. Scherer believes that this colouring matter is formed from the hæmatin of arterial blood, and that the amount of carbon contained

in pathological conditions of the urine can only be ascertained by the analytical proceedings described in pages 118 and 137.

6. *Increase or diminution of the fixed salts.*

The qualitative and quantitative variations occurring in the mixture of the fixed salts of the urine in disease are deserving of much attention. Some of these changes may be recognized without difficulty.

a. *Increase or diminution of the earthy phosphates.*

There are certain diseased states of the system in which the earthy phosphates are absolutely increased to a very marked degree; there are others, again, in which they decrease in an extraordinary manner, or even altogether disappear.

α. It is no very rare occurrence for the free acid of the urine to become neutralized by the formation of ammonia, and the urine thus becoming neutral or even alkaline, the earthy phosphates are precipitated. Urine in which these events occur is most commonly light-coloured; sometimes, however, dark. Blue litmus paper is not at all reddened by it, in fact red litmus is usually rendered slightly blue, and in some cases a powerful alkaline reaction is manifested. Generally speaking, the urine is clear and slightly acid at the period of its emission, but in a very short time it undergoes the change we have stated; a change which also occurs in normal urine, but not till after the lapse of several days. It becomes turbid, a film is formed on the surface in which minute crystals may be frequently detected with the naked eye. A sediment shortly begins to form, and at the same time the inner surface of the glass which contains the urine becomes covered with a stratum of salts; at least I have observed this to occur in several instances. Sediments of this kind are sometimes scanty, sometimes very copious. I have seen a case in which the sediment, which consisted almost

in this pigment varies inversely with the degree of oxidation of the blood; that its formation is analogous to the formation of uric acid and urea; that the carbon and hydrogen contained in it do not increase in an equal ratio; and that, finally, a long-continued secretion of urine, rich in this colouring matter, usually induces anæmia and emaciation. (Med. Times, Oct. 11, 1845.)]

entirely of earthy phosphates, occupied, when it had entirely settled, one third of the volume of the fluid. I received from a physician of this city, a portion of dried urinary sediment which consisted almost entirely of pure earthy phosphates. This fragment bore evident traces of the form of the glass in which the urine had been kept, and it was of the extraordinary thickness of nearly an inch and a half. Earthy-phosphate sediments are seldom perfectly pure; their colour is white, gray, yellow, or reddish. White and gray sediments consist principally of earthy phosphates and mucus; yellow and reddish sediments contain a greater or less admixture with urates.

That the sediment is composed of earthy phosphates we are assured by the following chemical facts. The urine from which it is precipitated is neutral, or more commonly alkaline; the sediment does not dissolve on the application of heat, like the urates; it is, however, readily dissolved by the addition of an acid (hydrochloric, nitric, or acetic,) to the urine; a property which is not enjoyed by sediments of the urates, of mucus, or of pus. If the sediment contain so large a proportion of urates and mucus that the addition of an acid does not produce any obvious degree of clearing, the acidulated urine must be gently warmed and filtered from the insoluble constituents. Upon the addition of free ammonia to the clear, filtered fluid, the earthy phosphates will be precipitated.

The nature of the sediments may be still more quickly ascertained by the microscope. If the sediment consists of earthy phosphates, we observe the beautiful crystals of ammoniaco-magnesian phosphate depicted in fig. 27, and also amorphous masses of phosphate of lime, fig. 26. Upon the addition of a minute quantity of free acid to the objects on the field of the microscope the crystals and amorphous masses immediately disappear, and at the same time numerous air-bubbles are liberated. If the earthy phosphates have been dissolved by a little acidulated water from the urates and mucus or pus, with which they were associated, and are then precipitated from the filtered solution by free ammonia, the precipitate exhibits other forms under the microscope.

I have represented these forms, which seem to vary according to circumstances, in fig. 30. Fig. 30 *a* exhibits the different forms under which the ammoniaco-magnesian phosphate is pre-

cipitated, in which the predominating character is the forked arrangement of the crystals. Fig. 30 *b* exhibits the forms in which the phosphate of lime appears.

The quantitative determination of earthy-phosphate sediments presents no difficulty, if other constituents are not also present. The method of proceeding is exactly the same as for the quantitative determination of the urate-of-ammonia sediment in page 176. Its amount must be determined in reference to the whole quantity of urine, and to the amount of solid residue.

In order to separate the earthy phosphates from urates, and mucus or pus, the sediment must be collected, washed with a weak solution of ammonia, the earthy phosphates taken up by water acidulated with hydrochloric acid, precipitated from the filtered solution by free ammonia, collected on a filter, dried, and weighed. Upon submitting the dried precipitate to a strong heat the ammonia is given off, and the weight proportionally diminished. The ratio of the earthy phosphates to the solid residue of the urine enables us to determine whether an increase in this particular class of constituents has occurred. If the relative quantities of phosphate of lime and ammoniaco-magnesian phosphate are required, the separation must be conducted on the principles described in page 139.

β. Diminution of the earthy phosphates. There can be no doubt that in certain diseases the earthy phosphates are much diminished, and that occasionally they altogether disappear. If the amount of earthy phosphates in the urine should be so slight that, upon the addition of free ammonia no precipitate is observed, it will be necessary, in order to be assured of the entire absence of this constituent, to evaporate a large quantity of urine, to incinerate the solid residue, to dissolve the ash in water containing a little nitric acid, and then to add ammonia. If no precipitate is formed after the fluid has been warmed and allowed to rest for some hours, the absence of earthy phosphates may be considered as proved.

b. Increase or diminution of the chloride of sodium and of the fixed alkaline sulphates and phosphates.

The quantity of fixed alkaline salts almost always decreases

during disease, principally in consequence of the diminution of the chloride of sodium, which, however, is by no means one of the most important of the saline constituents, and whose weight may be determined in the manner described in page 140. It is different, however, with the alkaline phosphates and sulphates, which (more especially the sulphate of potash,) appear to fluctuate considerably in disease.

We may readily be convinced of the presence or of the total absence of the aforesaid salts in urine which has become modified by disease, by the application of certain tests, or by the methods which have been enumerated in page 130, under 9, 10, and 11; indeed the practised experimenter will be able to judge from the specific gravity whether there is any decided increase or diminution in the amount of the fixed alkaline salts.

As, however, it is of importance to know the exact amount of the alkaline sulphates and phosphates in certain diseases, we must adopt the method described in page 140, and determine the relation of these salts to the solid residue.

7. *Increase of mucus.*

In catarrhal affections of the bladder the amount of mucus in the urine is often very much increased. The urine in these cases is acid or neutral, but frequently exhibits a strong tendency to become ammoniacal in a short time. The colour is usually unaffected, and seldom higher than ordinary. If there is a very large proportion of mucus in the urine, a diffuse sediment of a viscid consistence, and of a white, yellowish, or dirty yellow colour, will separate itself.

If the urine exhibits a strong tendency to the formation of ammonia, the mucus will become very tough, and almost thready. The supernatant fluid is somewhat turbid, but heat induces no coagulation unless albumen be present.

The mucus may be recognized under the microscope by the peculiar mucus-granules, which are usually rather larger and less granular than those from the mucous membrane of the lungs or nose.

I have represented the mucus of the bladder, as it occurs in certain pathological states, in fig. 31 *a*.

Mucus frequently accompanies sediments of the urates and earthy phosphates, and its presence in these cases may be detected by the microscope. When mucus is separated in large quantity, (as in vesical catarrh,) carbonate of ammonia is soon formed, and we always find numerous crystals of ammoniaco-magnesian phosphate.

The quantitative estimation of the mucus must be effected in the manner described in page 135. The ratio of its weight to that of the solid constituents must be determined.

In order to ascertain the quantity of mucus in a sediment of urates and earthy phosphates, the sediment must be collected, the urates dissolved in hot water, and the earthy phosphates then taken up by acidulated water. The mucus will remain on the filter, and must be dried and weighed.

The method of conducting the quantitative analysis of diseased urine is precisely the same as for the healthy secretion, provided the changes are only dependent upon an increase or diminution of one or more of the normal constituents: indeed it may be still more simplified by omitting the exact determination of the lactic acid, the lactates, the chloride of ammonium, and the extractive matters.

The proportions of water and of solid residue must be determined, in the manner already described, from a weighed quantity of filtered urine. The residue, after being dried over sulphuric acid, must be moistened with a little warm water, and then thoroughly extracted with anhydrous alcohol. The undissolved portion must be dried, weighed, and incinerated. The extractive matters and uric acid are consumed, and there remain the earthy phosphates, the alkaline sulphates and phosphates, and the chloride of sodium, which must be separated and determined.

The anhydrous alcoholic solution must be gently evaporated, dried over sulphuric acid, weighed, and dissolved in a little water. The urea must be then precipitated as a nitrate, which must be separated and dried in the ordinary manner, weighed,

and the weight of urea calculated from it. By subtracting the weight of urea from that of the whole of the alcohol-extract, we obtain as a residue the lactates, chloride of ammonium, alcohol-extract, and lactic acid, if any should be present.

The uric acid must be determined from a separate portion of urine. If any sediment occurs in the urine, it must be separated, and its weight ascertained in relation to the weight of the urine. After having ascertained its general nature, its various constituents must be determined by the methods already given.

If the morbid urine contains substances which do not occur in the healthy secretion, this method will even then often hold good, since the abnormal ingredients are sought for by independent processes. In many cases, however, a change is requisite; and I shall proceed to notice the various cases that may occur.

1. *Qualitative and quantitative determination of substances which do not occur in normal urine.*

Albumen is frequently present in the urine of persons suffering from disease, and indeed I once found it in the urine of a healthy vigorous young man, aged twenty-six years. If there is a considerable amount of albumen, nitric acid or bichloride of mercury will cause a precipitate, and the urine will become turbid on the application of heat, and deposit flocculi of coagulated albumen. Urine of this sort is usually pale and slightly turbid from containing mucus in suspension: its colour may, however, be high, as in the phlogoses; it may have an acid, neutral, or alkaline reaction, a high or a low specific gravity. When the quantity of albumen is very small, the application of heat is the most efficient test, and the most minute quantity of albumen may be readily detected by observing the uppermost part of the column of the fluid as it is being gently heated in a test-tube. When the temperature is sufficiently elevated, the coagulation begins to occur in the form of small white nebulæ, which are dispersed by the rising of large bubbles, and the general turbidity of the whole fluid is often so slight that unless the development of these nebulæ has been observed at the commencement of the process, it becomes a matter of difficulty to decide upon the presence of albumen. It is only in cases in which

the urine has a decidedly alkaline reaction that nitric acid is preferable for the detection of small quantities of albumen, as in these instances the albumen is held in solution by the free alkali.

A turbidity may occur on the application of heat from the precipitation of earthy phosphates, or possibly of carbonate of lime, when no albumen is present; but in this case it is directly removed on the addition of nitric acid: similarly, nitric acid may throw down a deposit of uric acid, which may be mistaken for albumen, but in this case no precipitate is caused by the application of heat. Dr. G. O. Rees has observed, that after the use of cubebs or balsam of copaiva, the urine is rendered turbid by nitric acid, although it contains no albumen; it is, however, not affected by heat. Hence, if there should be a tendency to the deposition of phosphates, a precipitate might ensue both on heating, and on the addition of nitric acid, and yet no albumen be present. I have confirmed the accuracy of the above observation; the precipitate consists of minute oil-vesicles readily soluble in alcohol, and possessing an odour of balsam of copaiva.

The quantitative analysis of albumen is best effected by boiling the urine, collecting the albumen on a filter, washing, drying, and weighing it, and ascertaining its weight in relation to that of the urine which was boiled, and to the solid residue. The portion of urine from which the albumen has been separated by boiling, may also be used for the determination of the other solid constituents and of the urea, if the quantity of albumen is not very large, and if the coagulated albumen is carefully washed. If the proportion of albumen is so large as to cause the urine to gelatinize on being heated, which, however, is very seldom the case, it may be feared that the coagulated albumen will entangle many other substances; in that case, the amount of solid constituents may be determined from a fresh quantity of urine, about 500—600 grains; the coagulated albumen must be treated several times with hot water before it is dried. When the quantity of albumen is very small, as for instance when the urine becomes only slightly turbid on heating, its amount cannot be determined with accuracy. It is then contained in the water-extract, and it is sufficient to state that the urine contains traces of albumen. If the amount of albu-

men is very considerable, certain changes must be made in the method of determining the other constituents. The albumen itself must be always separated by boiling.

In determining the urea we must see whether, when the albumen is very abundant, the greater quantity of it cannot be precipitated by alcohol. The albumen thus separated must be washed with alcohol. If we were to attempt to determine the urea in very albuminous urine in the manner described in page 136, there would be reason to apprehend that the albumen precipitated by the application of heat would entangle too large an amount of urea.

The determination of the uric acid is usually regarded as very uncertain in strongly albuminous urine. I have, however, convinced myself that this constituent may be separated from very albuminous urine by the careful addition of extremely diluted hydrochloric acid, [or acetic acid may be used, which precipitates uric acid without affecting the albumen.] It must also be observed that urine which is very rich in albumen always contains only mere traces of uric acid, and a very small proportion of urea.

In the determination of the water-extract, it must be borne in mind that albumen is present in it. As its quantity is known, it must be subtracted from the combustible portion of the water-extract.

The spirit-extract is obtained from the portion of urine precipitated by alcohol, where it occurs in a state of solution. This solution must be filtered, evaporated, and all substances insoluble in anhydrous alcohol precipitated by the addition of that reagent. These are spirit-extract with chloride of sodium, and a certain quantity of albumen which remains insoluble on the addition of water. The watery solution of the spirit-extract and of the salts must be filtered, again evaporated, weighed, and then treated in the manner described in page 137.

If we wish to avail ourselves of the alcoholic solution which remains after the precipitation of the spirit-extract by anhydrous alcohol, for the estimation of urea, we must take another portion of urine for the determination of the alcohol-extract and ammonia-compounds, and proceed in the same manner as for the determination of the urea.

In the determination of the fixed salts it must be remembered

that the earthy phosphates are increased by the phosphate of lime associated with the albumen, and as this generally amounts to 6 or 7 per cent., a corresponding amount must be deducted from the earthy phosphates. In other respects the method described in page 140 must be adopted.

[The following method for determining the amount of albumen has been recently proposed by Heller,[1] and offers several advantages.

A small quantity of the urine (from 20 to 10 grains) must be carefully weighed, and its solid residue accurately determined. In this way we estimate the per centage of solid residue. Another portion must be rapidly heated to incipient ebullition in a small narrow-mouthed flask. The mouth must be then closed, in order to prevent the escape of vapour, and the liquid when cold strained through a moderately fine linen cloth. The strained fluid is thus obtained perfectly clear, the albumen remaining on the linen as a snow-white magma. By treating a small quantity with nitric acid, we may be certain that the albumen is completely separated. The amount of the solid residue yielded by the strained fluid is determined, and the per centage calculated. The difference gives the per centage of albumen. If extreme accuracy is required, the flask with its contents may be weighed both before and after ebullition, and a correction made for the escaped vapour. In case the fluid should be alkaline, it must be previously acidulated with acetic acid.]

2. *Constituents of the blood with the exception of fibrin.*

Bloody urine is not of very unfrequent occurrence; it is distinguished by a more or less marked blood-red colour, sometimes being of a brown-red, and on other occasions even of a brownish black tint. No certain conclusions regarding the presence of blood can, however, be deduced from the colour alone. I have seen urine in colour strongly resembling bloody urine which contained not a trace of hæmatoglobulin. Various resemblances to the colour of blood may be induced by mixtures of considerable quantities of hæmaphæin, of uroerythrin,

[1] Archiv für phys. und patholog. Chemie und Mikroskopie, vol. 1, p. 192.

and of biliphæin. The presence or absence of the constituents of the blood may, however, be easily determined by the microscope, and by certain tests. If undissolved blood-corpuscles remain in the urine, as is frequently the case, they sink to the bottom and form a dark brown-red sediment, in which their forms may be recognized by the microscope. The dark-red supernatant fluid coagulates on the application of heat, in the same manner as ordinary albuminous urine; the coagulated matter, however, in this case is not white, but of a dirty brown colour. Similar appearances are produced by the addition of nitric acid. If the blood-corpuscles are perfectly dissolved in the urine, as I have sometimes observed to be the case, the microscope affords us no assistance. The application of heat, and the addition of nitric acid will, however, be sufficient to convince us directly of the presence of albumen and hæmatoglobulin.

The quantitative determination of blood in urine, and the changes which must be made, in consequence of the presence of a considerable quantity of that fluid, in the determination of the normal constituents are precisely similar to those already described in speaking of albuminous urine. It must be observed that the ash becomes reddened by the peroxide of iron which occurs in the hæmatin; and the fixed alkaline salts, as well as the earthy phosphates, are increased by the fixed salts of the blood, which usually amount to about 8 per cent.

3. *The constituents of the blood generally.*

Fibrin has been found associated with the other constituents of the blood which we have described as occasionally occurring in the urine.[1] Urine of this sort resembles blood in appearance; assumes, on being allowed to rest, a gelatinous consistence; trembles on the movement of the vessel; and, finally, separates into two portions, a clot, and thin fluid serum.

On examining, under the microscope, a little of the fluid obtained by pressing a portion of the clot, blood-corpuscles are

[1] [Fibrin has been detected occurring in a state of solution in urine, independently of the other constituents of the blood. Zimmerman describes seven cases of this nature, some of which are noticed at length in a future part of this chapter. (Zur Analysis und Synthesis der pseudoplastischen Prozesse. Berlin, 1844, p. 129.)]

observed: and upon kneading the clot in water we obtain fibrin, which may be washed perfectly pure. Under these circumstances there is no difficulty in ascertaining the presence of blood. If the blood has coagulated in the bladder, the urine will be of a blood or brown-red colour, or even of a brownish-black, and will contain gelatinous flocculent coagula of fibrin, which, after remaining for some time in the urine may acquire a degree of transparency by the solution of their colouring matter.

It is only necessary, in these cases, to make sure that the coagula are not composed of mucus, a point which can be readily settled by the microscope, under which coagula of fibrin, upon compression between thin glass plates, present an amorphous granular appearance, while in the mucus-flocculi we recognize the well-known mucus-granules.

The quantitative determination of the constituents of the blood must be conducted in the manner described in 2. A method perfectly similar to the one which I have given for the analysis of blood may, however, be adopted, and in order to determine the urea in a certain quantity of bloody urine, the protein-compounds must be precipitated with alcohol, in the same manner as in albuminous urine.

4. Urine may contain fat either as an independent extraneous constituent, or associated with albumen, or with casein and the other constituents of milk. To distinguish these three morbid forms of urine we may term them, for brevity, *fatty urine*, *chylous urine* (Prout), and *milky urine*. In addition to these forms, urine containing blood always contains, of course, a relatively corresponding quantity of fat.

Fatty urine. We occasionally observe that the urine of persons labouring under consumptive disorders becomes covered over with a glistening film. It would be precipitate to consider this, without further investigation, as a fatty coat, since I have observed a similar appearance on the surface of urine which had been standing for some time, and was just becoming ammoniacal. The microscope will immediately disclose the nature of the film: if it is composed of fat, we observe, on the microscopic examination of a small portion, an immense number of fat-globules;

in the other case, we observe an amorphous granular matter. Cases have however occurred in which the urine has contained so large a quantity of fat that the oil-vesicles could be observed even with the naked eye, and formed a perfect stratum on the surface;—such cases have been recorded by Elliotson and Bachetoni.[1]

The microscope is always sufficient for the recognition of fat in urine. If a quantitative determination of the fat is required, a weighed portion of urine must be evaporated and the residue repeatedly extracted with ether. The ether must then be evaporated, and the fat separated from the urea, and other constituents which may have been also taken up by means of water. This separation should be effected in a small porcelain basin, in which the fat must be heated till all aqueous moisture is dissipated, and then weighed. If the amount of solid residue is known either by this, or a separate experiment, the proportion of fat to the urine, and to the solid residue, can be at once obtained. The residue, after the separation of the fat, will serve for the determination of other constituents, as urea or extractive matters; it must however be remembered that the water in which the fat was washed, contains some little urea.

Chylous urine. Chylous urine contains both fat and albumen; it is usually turbid, curdy, sometimes even resembling milk in point of colour. Under the microscope it exhibits numerous fat-vesicles. On the addition of a small quantity of acetic, or dilute sulphuric or hydrochloric acid, no coagulation occurs, even when gentle heat is applied; but on the addition of nitric acid a white precipitate is observed. Upon the application of heat to chylous urine, the albumen coagulates in flocculi. The methods of determining the amount of albumen and fat have been already given.

5. *Casein.*

Casein has never yet, so far as I know, been observed as a single extraneous constituent of the urine, as albumen sometimes seems to occur, but has always been found in combination with fat, and, in all probability, also with sugar, forming milky urine.

[1] Urinary Diseases and their Treatment. By Robert Willis, M.D. p. 166.

Milky urine is always turbid, of a yellowish-white colour, sometimes like milk, and when examined under the microscope, exhibits a quantity of fat-vesicles. Upon the application of heat to urine of this nature, coagulation will take place if a considerable amount of lactic acid is present, and then only a moderate temperature (86° to 104° F.) is sufficient. If it does not coagulate at this temperature, neither will it do so at the boiling point, as I have proved in an experimental mixture of milk with urine. If, however, albumen should also be present, the urine will coagulate on being boiled. On the addition of a few drops of acetic, or dilute sulphuric or hydrochloric acid to a little of this urine, flocculi of coagulated casein will be formed if a moderate heat is applied. In order to determine the quantity of casein we must add a little acetic acid to a weighed portion of moderately warmed urine, and allow it to digest till the white flocculi of acetate of casein have separated themselves, and the urinary fluid has become clear.

The flocculi must be collected, washed, dried, and weighed. This is most readily effected on a light filter of known weight, which must be deducted, in order to give the true weight of the casein. The fat becomes entangled in the precipitated acetate of casein, and the filtered fluid exhibits only a few scattered fat-vesicles swimming in it. The fat may be separated, and its amount determined, either from the dried residue of the urine, or from the dried casein, by extraction with ether. The casein must be determined from a separate portion of urine; after this constituent has been separated the urine may be evaporated, and the urea and water-extract determined from the residue.

6. *Brown pigment of the bile.* (*Biliphæin.*)

It is no uncommon occurrence to find the urine tinged with this substance; in icterus it is always present. Urine of this sort is of a saffron, dark yellow, or yellowish-brown colour, and its sediment, if it contains one, is usually of a yellow or brown colour also. We cannot, however, always decide upon the presence of biliphæin from the colour of the urine, since hæmaphæin (the peculiar colouring matter of the urine) is capable of producing a similar tint. It is a peculiarity

of urine coloured dark by biliphæin, that it exhibits in thin layers a characteristic saffron yellow colour. The presence of biliphæin may be at once detected with certainty by the addition of nitric acid, by which the well-known transitions in colour, from green to violet, red, and yellow are produced. It is only when there is a considerable quantity of biliphæin present that these transitions can be distinctly observed, and the best method of proceeding is to pour a layer of urine carefully over nitric acid, and to continue the mixture of the two fluids gradually.

When the quantity of biliphæin is very small, the only changes that we are certain to observe on the addition of the nitric acid, are the transition of the yellow colour of the urine into green, which usually reverts to a yellow, without the intermediate colours being observed. Hydrochloric acid converts the yellow or brown colour of the urine into green, but does not develop the other tints.

An exact quantitative determination of the biliphæin in urine appears, with our present resources, hardly practicable, for its amount is usually very minute, and, like the animal colouring matters generally, it possesses the property of combining very intimately with other constituents. Thus we find uric acid, when it occurs as a sediment in icteric urine, mucus, the extractive matters, &c. always tinged yellow by biliphæin. We must therefore be content, in our estimation of the amount of the biliphæin, to draw our inferences from the intensity of the colour of the urine, and from the degree of change that it undergoes on the addition of nitric acid.

7. *Bilin and bilifellinic acid.*

The quantity of bile in urine is occasionally so large as to communicate to that fluid a decidedly bitter taste: in these cases biliphæin is always present. Whenever biliphæin occurs in urine, we are justified in suspecting the presence of bilin and bilifellinic acid, although they are not always found.

When the taste of the urine does not decidedly indicate the presence of bilin and of the acids of the bile, we must, in order to be assured of their existence, evaporate the urine, extract the residue with anhydrous alcohol, and then expel the alcohol by

evaporation; the residue will contain bilin and bilifellinic acid, in addition to urea, alcoholic-extract, and the lactates; their presence may be recognized by the taste.

[The best method of ascertaining the presence of bilin (or choleic acid) is one recently published by Pettinkofer.[1] A small quantity of the urine or other fluid, supposed to contain bile, must be poured into a test-tube and treated with about two thirds of its volume of sulphuric acid, added by drops. Considerable heat is evolved, and the mixture must be kept below 144°, otherwise the bilin will be decomposed. A few drops of a solution of cane-sugar (five parts of water to one of sugar) are added, and the mixture shaken. If bilin be present, a violet-red colour will appear, the distinctness of which will vary with the amount of bilin. The following precautions must be attended to:—1st, the temperature must not exceed 144°, otherwise the colour, although formed, will be again destroyed: 2dly, the quantity of sugar must not be too large, lest sulphurous acid should be formed, and the solution become of a dark brown colour: 3dly, the sulphuric acid must be free from sulphurous acid: 4thly, if albumen be present, it is advisable to coagulate and remove it before applying the test, since it gives origin (when present in a large quantity) to a tint somewhat resembling that produced by bilin: 5thly, a great excess of chlorides produces a brownish-red colour.

In liquids where the bile is in very small quantity, as in the urine and other secretions, it is often necessary to make a spirituous extract, to evaporate this nearly to dryness on the water-bath, and to transfer the moist residue into a watch-glass. When quite cold, sulphuric acid and a very small quantity of syrup are added, so that the temperature of the solution remains low. In the course of a few minutes, if the most minute trace of bile is present, the colour is produced. In employing this test grape-sugar, or any substance convertible into grape-sugar, may be substituted for cane-sugar.

The nature of this reaction is unknown; it was at first considered that the peculiar violet tint might be dependent on the decomposition of the bile-pigment, but it was found to occur,

[1] Liebig's und Wöhler's Annalen, vol. 52, part 1.

even in a more marked degree, with decolorized bile, and with pure bilin.

Another test has been recently proposed by Schwertfeger. He recommends that the urine should be treated with basic acetate of lead. When bile is present the precipitate is yellow. On treating this precipitate with alcohol containing some sulphuric acid, we obtain a green solution, to which (as has been suggested by Dr. Griffith) Pettinkofer's test may be applied with advantage.]

For the purpose of forming a quantitative analysis of the bilin in the urine, we must evaporate a weighed portion, precipitate the water-extract and the salts insoluble in alcohol with spirit of 0·85, evaporate the spirituous solution, and extract the residue with anhydrous alcohol. The alcohol of this last solution is expelled, the residue dissolved in a little water, and some hydrochloric acid added; it is then allowed to digest till the resinous matter of the bile has separated itself, which must be washed, dried, and weighed. The presence of bile offers no impediment to the determination of the urea, for which purpose, however, a different portion of urine must be used.

When icteric urine contains a sediment, it is usually of a yellow or brown colour, and in addition to the ordinary constituents of urinary deposits, it contains biliphæin. The sediment, in these cases, must be separated, and extracted with alcohol. This alcoholic solution must be united with the spirituous solution of the residue of the urine, from which the bilin was determined. The sediment must be analysed according to the rules already laid down for the separation of uric acid, the urates, and earthy phosphates.

8. *Sugar.*

In diabetes mellitus the urine frequently contains a large quantity of grape or diabetic sugar, while the urea is at the same time either absolutely or relatively diminished. When the quantity of sugar is considerable its presence can be detected without difficulty. The urine must be evaporated, and the syrupy residue treated with alcohol of 0·83. The alcoholic solution must then be evaporated till a yellow and very sweet syrup is left. Trommer, of Berlin, has discovered that the smallest quantity

of grape-sugar may be detected in a fluid by the addition of a solution of sulphate of copper and of caustic potash.[1] On heating the mixture we do not obtain a black precipitate of oxide of copper, but the fluid becomes turbid, and a more or less considerable yellow, or yellowish-brown precipitate of reduced suboxide of copper is thrown down. According to the statements of Trommer, this method is particularly applicable to the detection of very minute quantities of diabetic sugar in urine; but since the ammonia-salts, the urea, and nitrogenous extractive matters, when heated with caustic potash, develope free ammonia, which impedes the action of the test, it is better to proceed in the following manner. The urine must be evaporated and the syrupy residue treated with anhydrous alcohol. Dry carbonate of potash must be added to this solution, and the mixture well shaken. The carbonate of potash dissolves and forms a layer beneath the alcohol. Upon the addition of some dissolved sulphate of copper, and the application of heat, there is produced in the lower portion of the fluid, a yellow or yellowish-brown turbidity, if sugar is present. Trommer states that this method is equally applicable for the detection of sugar in the blood.

The quantitative determination of sugar in urine is not very easy: I proceed in the following manner. A weighed quantity of urine is evaporated on the water-bath to the consistence of a thin syrup, and the residue treated with alcohol of 0·85, which precipitates the mucus, the salts insoluble in spirit, the water-extract, uric acid, &c. The spirituous solution is then evaporated to the consistence of a thick syrup, and anhydrous alcohol added, which precipitates the greater part of the sugar in the form of a yellowish-white magma. On pouring off the supernatant yellow alcohol, and repeatedly treating the magma with anhydrous alcohol, it gradually assumes a tough pasty form: it must then be warmed for some time on the water-bath, until all the alcohol is expelled, and be subsequently placed under a receiver over sulphuric acid, to dry. Ether is then added to the alcohol, in about the proportion of one volume of the former to two of the latter, by which an additional quantity of sugar is precipitated, whose weight must be determined

[1] See Vol. I, p. 68. Additional observations on the application of this test will be found in the remarks on the urine in diabetes.

separately. The substances now remaining in solution in the etherealized alcohol are urea and alcohol-extract. The fluid must be evaporated or distilled, and the urea determined from the residue by nitric acid. The sugar separated in this manner is not perfectly pure; it still contains chloride of sodium, extractive matters, and, in most cases, a small quantity of urea.

From the portion precipitated from the urine (after it has been reduced to a thin syrup) by alcohol of 0·85, and which consists of water-extract, earthy phosphates, uric acid, and mucus, the water-extract may be taken up by water, and determined after evaporation. The earthy phosphates may be taken up by water slightly acidulated with hydrochloric acid, from which they may be precipitated by ammonia: uric acid and a little mucus remain. The uric acid should be determined from a separate quantity of urine, according to the method described in page 137, for by this process we frequently obtain mere traces of it, and sometimes no indication whatever of its presence. The determination of the fixed salts in diabetic urine is of importance. Hunefeld has observed that diabetic urine frequently contains more chloride of sodium than the healthy fluid, a circumstance probably arising from the diet which is most commonly observed during the disease in question. In order to determine the fixed salts, a portion of urine must be evaporated, and the residue incinerated. The perfect incineration of the residue is a matter of some difficulty: it may be facilitated by moistening the carbonaceous residue with nitric acid, and then submitting it to a red heat; or nitric acid may be added to the syrup at once, in which case a very large amount of carbon is burnt off immediately upon the residue being submitted to a red heat. The salts must be determined by the method described in page 139.

The exact determination of the solid residue of diabetic urine presents certain difficulties. A very small quantity of urine (from about 150 to 230 grains) should be evaporated in the water-bath, and the residue spread over the evaporating basin, which should then be placed under a receiver over sulphuric acid, for the perfect removal of the water. The quantities of sugar, urea, uric acid, &c. must be brought into relation with the amount of solid residue as well as with the whole quantity of urine.

Diabetic urine may also contain a tasteless species of sugar,

which, according to Bouchardat,[1] corresponds exactly in its behaviour towards yeast, and in its solubility in spirit, with sweet sugar, and may be separated in the same manner.

I have had one opportunity of examining diabetic urine, containing a slightly sweet sugar which was soluble in spirit, and also a considerable amount of insipid matter which was precipitated by alcohol, and appeared to resemble gum mixed with water-extract and mucus. I could not separate it from the water-extract, which is usually very scanty in diabetic urine.

9. *Carbonate of ammonia.*

In some diseases, especially in affections of the brain and nervous system, and of the bladder and kidneys, the urine possesses the property of becoming quickly alkaline; indeed I have observed instances in which it was alkaline at the period of its being passed. In these cases it has a very disagreeable, ammoniacal odour, and changes red litmus paper to a bright blue. In colour it may be either light or very dark; it ordinarily forms, in the course of a short time, a sediment of a grayish-white, and occasionally of a yellow or red colour, consisting of earthy phosphates. A certain test for the presence of carbonate of ammonia is afforded by holding a glass rod moistened in non-fuming hydrochloric acid over the urine; its existence is indicated by the formation of dense white vapours. On the addition of nitric acid to the filtered urine, numerous bubbles of carbonic acid gas are briskly developed. After a little practice the odour will be a sufficient indication of a very minute quantity of carbonate of ammonia. The quantitative analysis of this substance is seldom undertaken, but without doubt it is of importance, especially for the purpose of ascertaining whether an increase in the quantity of carbonate of ammonia necessarily involves a decrease in the amount of urea.

I have satisfied myself that in diseases of the spinal cord, when the urine often contains much carbonate of ammonia, it is formed at the expense of the urea. In four experiments, instituted with this object, I found scarcely a trace of urea in the urine.

An approximation to the amount of carbonate of ammonia

[1] [Bouchardat now regards this tasteless sugar as a compound of the ordinary diabetic sugar with salts.]

may be made in the following manner. Dilute hydrochloric acid of known strength must be added *guttatim* to a weighed quantity of gently warmed urine, till, from being alkaline, the fluid becomes slightly acid. This point being attained, the warmth is continued for some time in order to make sure that the acid reaction is not due to the carbonic acid that has been liberated. The amount of carbonate of ammonia is then estimated from the quantity of hydrochloric acid which has been used.

10. *Oxalate of lime.*

Oxalate of lime not unfrequently gives rise to urinary calculi. A compound resisting a solvent power of the moderate acidity of the urine cannot, of course, occur in it in a state of solution: it has, however, been detected several times in urinary sediments, for which reason I refer to it here. Prout and H. Brett[1] have observed these sediments. The latter writer states that the urine was very high-coloured, and that the sediment was of a brownish tint. He ascertained its nature by its ready solubility in dilute nitric acid without any indication being afforded of the presence of uric acid, by its becoming white on incineration, by the ash then dissolving in hydrochloric acid with considerable effervescence, and by oxalate of ammonia producing an immediate precipitate, while no marked effects followed the addition of ammonia in excess: by these characters the oxalate of lime was thoroughly and satisfactorily made out. I once found oxalate of lime in the urine of a man with induration of the pancreas and suffering from great acidity of the stomach. The urine was neutral, or all but alkaline, and contained the minute prismatic crystals represented in fig. 36 *d*. They were insoluble in acetic, but dissolved in hydrochloric acid; and a further investigation left no doubt of their real nature. After some days the urine became remarkably acid, and deposited a sediment devoid of oxalate, but containing carbonate of lime.

[I have already mentioned that oxalate of lime is a much more common ingredient of urinary sediments than was formerly supposed. (See Vol. I, p. 85.) In order to detect it, place urine, passed a few hours after a full meal, in a large test-

[1] Urinary Diseases and their Treatment. By Robert Willis, M.D. p. 118.

tube, and allow it to stand for some hours. Decant the upper 6-7ths, pour a portion of the remainder into a watch-glass, and gently warm it over a lamp; in a few seconds the heat will have dissolved any urate of ammonia that may be present, and will (by rendering the fluid specifically lighter) induce the deposition of the crystals of oxalate of lime. Having allowed the urine to repose for a minute or two, remove the greater portion of the fluid with a pipette, and replace it by distilled water. A white powder, often of a glistening appearance, will now become visible, and this, under a microscope furnished with a half-inch object-glass, will be found to consist of crystals of oxalate of lime in beautifully-formed transparent octohedra, with sharply-defined edges and angles. (Fig. 36 *a.*) This process is the most satisfactory, and, after a little experience, can be performed in a few minutes. But even this may be avoided by placing a drop of the lowermost stratum of the urine on a plate of glass, placing over it a fragment of thin glass or mica, and then submitting it to the microscope; the crystals diffused through the fluid becoming very beautifully distinct. In this way, however, it is obvious that very much fewer are submitted to examination than by the former process. This salt never (or scarcely ever) subsides to form a distinct deposit; remaining for days diffused through the fluid, even when present in so large a quantity that each drop of the urine, when placed under the microscope, is found loaded with the crystals. A large quantity of the oxalate, when present, may escape the eye, in consequence of its refractive power approaching that of the urine; for whenever we meet with a specimen in which the salt has partially subsided, and replace the decanted urine by distilled water, the crystals often become readily perceptible to the unaided eye, resembling so many glistening points in the fluid.

The crystals of the oxalate, when collected in a watch-glass in the manner above directed, are unaltered by boiling either in acetic acid or solution of potash. In nitric acid they readily dissolve without effervescing, and the act of solution can be observed with the microscope. When the oxalate is allowed to dry on a plate of glass, and then examined, each crystal resembles two concentric cubes with their angles and sides opposed; the inner transparent and the outer black, so that each resembles a translucent cube set in a black frame. (Fig.

36 *b*.) This is best observed under a half-inch object-glass; as with a higher power this appearance is lost.

In a very few cases the oxalate is met with in very remarkable crystals, shaped like dumb-bells, or rather like two kidneys with their concavities opposed, and sometimes so closely approximating as to appear circular, the surfaces being finely striated. (Fig. 36 *c*.)

The greatest possible variation in the size of these crystals is met with not only in different specimens of urine, but often in the very same portion. In a single drop of urine octohedra of oxalate of lime may be frequently observed mixed with others four or six times their size. Dr. Golding Bird has given the following measurements of some of his preserved specimens:

	inch.
Length of a side of the largest octohedra	$\frac{1}{750}$
" smallest ditto	$\frac{1}{5600}$
Long diameter of large "dumb-bell" crystals	$\frac{1}{363}$
Short diameter of ditto	$\frac{1}{750}$
Long diameter of the smallest "dumb-bells"	$\frac{1}{1420}$
Short diameter of ditto	$\frac{1}{3500}$

In the urine of the horse they are much larger, often being 1-150th of an inch long.

Many specimens of oxalic urine give a precipitate with salts of lime, insoluble in acetic acid, and consisting of oxalate of lime. This is often dependent on the presence of oxalate of ammonia, and delicate acicular crystals of this salt may be occasionally noticed, during spontaneous evaporation, on the border of the capsule.

Lehmann states that he has very frequently met with oxalate of lime in healthy urine, and that it often occurs in large quantity in cases of tuberculosis, arthritis, and especially of osteomalacia or softening of the bones. He has likewise met with it in endocarditis and other acute diseases. He states that the crystals are neither octohedra nor cubes, but four-sided double pyramids, which in their projection under the microscope appear as very minute cubes, or as somewhat larger octohedra. He further believes that a portion of the oxalate of lime is held in solution by lactic acid, and advises that if the urine be very acid, it should be neutralized, boiled, and allowed to cool slowly, before looking for the crystals.

For further information on this subject I must refer to the excellent little work by Dr. Golding Bird on 'Urinary Deposits,' from which the above observations are chiefly taken.]

11. *Carbonate of lime.*

[Carbonate of lime is a rare ingredient of urinary deposits. Dr. Griffith[1] describes it as consisting "of nuclei which were almost colourless, and studded with minute acicular crystals all over their surfaces."

It is occasionally met with in the alkaline urine common in cases of paraplegia following injury to the spine. In the majority of cases it forms an amorphous deposit mixed with prisms of ammoniaco-magnesian phosphate. More rarely it is met with regularly crystallized, in compound spherical crystals, apparently built up of an infinite number of close-packed needles, radiating from a common centre. The outline of these masses is irregular, and their periphery is often apparently serrated. (Fig. 30* *c.*) The carbonate of lime is normally present in the urine of many of the graminivora, especially of the horse. The dense deposit which forms in the urine of this animal consists of a mixture of carbonate and oxalate of lime. The former series form large spherical crystals like glass beads, which, when immersed in balsam, present the radiated acicular structure above described. (Fig. 30* *a b.*) Very beautiful evidence of structure is exhibited in these crystals of carbonate of lime when examined by polarized light; a series of coloured rings traversed by a black cross being visible.]

12. *Cystin.*

[Cystin, when present in the urine, forms a nearly white or pale fawn-coloured pulverulent deposit, resembling the pale variety of urate of ammonia.[2] It appears to be merely diffused through the urine whilst in the bladder, as at the moment of emission the secretion is always turbid, and very soon deposits a copious sediment. On applying heat to the urine, the deposit undergoes no change, which serves to distinguish it from urate

[1] Med. Gaz., March 1844.

[2] It is, however, always crystallized, a few regular six-sided laminæ being often seen, but the great mass consisting of numerous superposed plates, so that the compound crystals thus produced appear multangular, as if sharply crenate at the margin, (fig. 32 *b.*) They thus resemble little white rosettes, when viewed by reflected light.

of ammonia; its insolubility in strong acetic acid prevents it from being mistaken for earthy phosphates. The best character of cystin is its ready solubility in ammonia, mere agitation of some of the deposit with liquor ammoniæ being sufficient to dissolve it, and a few drops of the solution evaporated on a slip of glass leaving six-sided tables of cystin. (See fig. 32 *a*.) A certain portion of cystin exists in a state of solution in the urine, as the addition of acetic acid always precipitates a small quantity. Urine containing cystin usually develops a peculiar odour resembling that of the sweet-briar, and often exhibits a peculiar greenish tint. (See Urinary Deposits, p. 111.)]

13. *Pus.*

Pus is not easily detected in the urine, especially when a small quantity is mixed with a much larger amount of mucus. I must refer to what has been already stated in page 100 regarding the distinctions between pus and mucus; it must at the same time be remembered that the mucus of the bladder differs in its properties from the bronchial mucus, and is less easily distinguished by the naked eye from pus. Urine containing pus may have an acid, neutral, or (and that not uncommonly) an alkaline reaction; at least it exhibits in most cases a strong tendency to the development of ammonia. The colour and amount of solid constituents are subject, according to Willis, to great variations. There is only one property of purulent urine that can be considered specific, and that is the invariable presence of albumen; too much stress must not, however, be laid upon this point, since urine is frequently albuminous without containing a single particle of pus, and we may very easily mistake albuminous urine containg mucus for purulent urine. In order to detect the presence of pus with the greatest degree of certainty, the urine should be analysed as soon as it is discharged; it is then turbid, and very soon deposits a sediment, which, on the least motion of the glass, mixes with the fluid, and is again as quickly deposited. It forms an uniform substratum of a yellow, pale yellow-green, or yellowish-white colour, in which the presence of blood may also sometimes be recognized. On examining the sediment with the microscope, we find that it consists of pus-globules (fig. 17), which, by inclining the stage of the microscope, may be readily caused to move; and if the colour should lead us to infer the

presence of blood, the flattened blood-corpuscles may probably be observed. The pus-globules usually appear rather larger than the pus-globules of the lungs, and less granular; and I have observed that the nucleus can be more frequently recognized with clearness; the blood-corpuscles also appear tumid.

The filtered urine always contains albumen, sometimes in such quantity that flocculi separate on the application of heat. If the urine is allowed to stand for some time, and develops carbonate of ammonia, the pus becomes so viscid as to form a tenacious jelly. In these cases small quantities of albumen might escape notice on the application of heat, being held in solution by the carbonate of ammonia; to assure ourselves of the presence of albumen in these cases, we should make use of nitric acid.

In catarrhus vesicæ, in which a considerable quantity of mucus is frequently discharged, and where the urine is either thick and viscid at the time of emission, or very soon becomes so, a small quantity of pus may be easily overlooked.

URINE IN DISEASE.

On the general relations of the urine in disease.

Although I have, in the preceding pages, made many remarks on the general constitution of the urine in disease, I believe it will not be unacceptable to the practical physician if I offer some additional observations on the variations in the composition of this secretion, when it is pathologically changed.

The quantity of water in urine is always fluctuating, and may vary to a great extent; this point has been already referred to in our remarks on the physiology of the urine. The urine may exhibit remarkable differences in its external physical characters in persons suffering from the same disease,—a circumstance that analysis will enable us to trace to the different proportions of water that may be present. Frequent recourse to fluids, and the degree of activity of the process of transpiration must obviously have a very great influence on the amount of the watery portion, and therefore on the amount of the urine itself, and this is a point which the physician should never lose sight of in forming his opinion on the quantity of the discharged urine and on its degree of concentration. It is well known that the morning urine is more concentrated than that which is discharged during the day.

In consequence of the fluctuations, arising from various causes, in the amount of water in healthy urine, Becquerel[1] has come to the conclusion that its increase or diminution cannot be referred to the action of disease, except less than twenty-seven or more than fifty-two ounces are secreted in twenty-four hours, the average quantity in health being about forty-four ounces in that period.

The diseases in which the quantity of water separated by the kidneys is absolutely or relatively increased are diabetes in its different forms, and certain hysterical or nervous disorders in which a perfectly limpid and thin urine is discharged in large quantity: thus Becquerel relates a case of a young chlorotic girl who ordinarily secreted daily about thirty-seven ounces of water by the kidneys, but in whom the amount rose to ninety ounces upon the accession of a severe hysterical attack.

The amount of water separated by the kidneys is diminished in inflammatory affections, in which Becquerel has seen it fall as low as twelve ounces in twenty-four hours. In these cases the urine is of a very dark colour, of a high specific gravity, and possesses a strong acid reaction. As the quantity of water increases, the solid constituents relatively, but not always absolutely, diminish, as may be found by comparing them with the amount secreted in twenty-four hours in a state of health.

The quantity of urea was found by Nysten to be increased in inflammatory affections, and my own analyses of the urine during inflammation, on the whole, tend to confirm his statement; for I found it either absolutely or relatively increased, or equal to the quantity separated in a healthy state, or at any rate but slightly diminished. If we remember, however, that in these acute diseases only very small quantities of nitrogenous food are taken, and that the quantity of urea must naturally decrease under such a diet, we may regard it as increased even if it falls below the physiological average. Becquerel also found the amount of urea in acute diseases very little below the physiological mean.

The quantity of urea is diminished in diseases in which there is either an absolute deficiency of blood, or the blood is poor in corpuscles; thus Becquerel found the urine in chlorosis deficient in urea, and I have observed the same to be the case in the latter stages of typhus.

[1] Séméiotique des Urines, &c. p. 19.

The relative proportion of uric acid varies much in different diseases. We may conclude from the observations which have been made that the amount is increased by disturbances in the circulating system, as in the paroxysms of fever, in inflammations, &c. The following pathological conditions lead, according to Becquerel, to an increased quantity of uric acid: fever; great general functional disturbances, such as arise from oppressive dyspnœa in pulmonary emphysema or cardiac disease, acute pain, convulsions, delirium, &c. especially when attended with fever; and diseases of the liver, as hepatitis, cancer, or cirrhosis. The amount of uric acid is diminished in those cases in which there is a deficiency of blood, or where the blood is poor in corpuscles. Becquerel found this to occur in cases of chlorosis and anæmia, and in persons in whom the vital juices seemed dried up. The amount of the salts in the urine fluctuates extremely during disease. Generally speaking, we may assume that the quantity of salts decreases in most pathological states of the system; the cases in which the salts increase during disease being very rare. Becquerel states that in those diseases in which the amount of urea is only slightly diminished, the proportion of salts is not materially affected; but that in those cases in which the urea suffers a considerable reduction, the same takes place with regard to the salts. Analyses of inflammatory urine are, however, opposed to this statement, since in these cases the urea sometimes exceeds the normal amount, while the salts are decreased in an extraordinary manner. It is to be regretted that Becquerel has not undertaken an exact quantitative separation of the different salts, as the increase or decrease of the fixed salts collectively is a circumstance of much less importance than the varying relative proportions of the individual compounds.

ON THE CONSTITUTION OF THE URINE IN DIFFERENT DISEASES.[1]

Urine in the Phlogoses.

In inflammatory affections, and in those diseases which are accompanied by that form of fever which is termed sthenic

[1] Becquerel has attempted to classify every form of morbid urine under one of the

or synochal, the urine differs greatly in its properties from normal urine. In speaking of the probable cause of the changed constitution of the blood in the phlogoses, (see Vol. I,

four following heads: 1st, Febrile urine; 2d, Anæmic urine; 3d, Alkaline urine; 4th, Urine differing but slightly from the normal standard.

1st. Febrile urine presents three distinct varieties:

α. Febrile urine, in the strict sense of the word, is passed by persons suffering from fever, or with severe functional disorders. This urine is characterized by a considerable diminution in the quantity of the water discharged by the kidneys in twenty-four hours, and by a slight diminution in the amount of the solid constituents, the urea and inorganic salts being below the daily healthy average, while the uric acid is increased. It is of higher specific gravity than normal urine, its colour is deeper and redder, it is frequently turbid, and often contains a small quantity of albumen. Becquerel gives the following analysis as a type of this form of urine: I place his analysis of healthy urine by its side, in order to render the differences in the two fluids the more striking:

	True febrile urine.	Healthy urine (Becquerel.)
Quantity of urine in twenty-four hours	23 ounces	45 ounces
Specific gravity	1021·8	1017·0
Water	964·0	972·0
Solid constituents	36·0	28·0
Urea	13·2	12·1
Uric acid	1·5	0·4
Other organic matters	14·7	8·6
Fixed salts	7·1	6·9

The urine is stated to assume the true febrile character in severe functional derangements, in chronic and acute inflammations, in general hyperasthenia, in diseases of the liver, the heart, and the lungs; in hemorrhages during their continuance, and in such organic degenerations of the different organs as result from fever or functional derangement.

β. Febrile urine, accompanied with great debility. In this variety of urine the water is likewise diminished. The specific gravity of the urine and the amount of solid constituents are considerably less than in the former case. With the exception of the uric acid, which remains normal, all the other constituents are absolutely, although not relatively, diminished.

The following analysis is given by Becquerel as a type of this variety of urine:

Quantity of urine in twenty-four hours	21 ounces
Specific gravity	1014·7
Water	974·0
Solid constituents	26·0
Urea	7·3
Uric acid	0·8
Other organic matters	10·5
Fixed salts	4·2

This form of urine is less concentrated than the normal secretion, is deeply coloured, and often turbid from the spontaneous deposition of uric acid. It occurs in those cases of fever in which there is great prostration and debility arising either from the

p. 284,) I showed that it is not to be referred to the diseased organ, but to the reaction which manifests itself throughout the vascular system. If the change in the constitution of

disease itself or from very energetic treatment, such as free venesections or repeated purgations.

γ. Febrile urine in which the quantity of water is not affected. In this variety the daily amount of water is not less than in health; the urea and fixed salts are diminished; the uric acid and other organic matters are normal. The composition is illustrated by the following analysis:

Quantity of urine in twenty-four hours	45 ounces
Specific gravity	1010·5
Water	982·8
Solid constituents	17·2
Urea	6·8
Uric acid	0·3
Other organic matters	7·5
Fixed salts	2·6

The specific gravity is low, although the colour is usually deep. It does not deposit any sediment, and even, after the addition of an acid, there is often no precipitation of uric acid.

2dly. Anæmic urine. This form of urine usually occurs in anæmia, chlorosis, &c. It is divided by Becquerel into the two following varieties:

α. True anæmic urine. The amount of water discharged by the kidneys in twenty-four hours is almost normal, while the solid constituents are considerably less than in healthy urine; the urea, uric acid, and fixed salts being much diminished, and the other organic matters decreased in a slighter degree. Its specific gravity is low, it is not deeply coloured, and it deposits no sediment. Its constitution is well represented in the following analysis:

Quantity of urine in twenty-four hours	38 ounces
Specific gravity	1010·3
Water	982·8
Solid constituents	17·2
Urea	6·51
Uric acid	0·25
Other organic matters	6·23
Fixed salts	4·20

β. Concentrated anæmic urine. In this form of urine the water discharged in twenty-four hours is much diminished, and the amount of solid constituents, although relatively increased, is absolutely diminished also. The urea, uric acid, and fixed salts are the most diminished; the other organic matters less so. This urine is of a green or livid tint, and is never red or yellow.

3dly. Alkaline urine. This variety is distinguished by its alkaline reaction on test-paper and by its ammoniacal odour. (When the urine has become alkaline by the use of bicarbonate of soda there is no ammoniacal odour developed.) It has been observed by Becquerel in acute and chronic nephritis, in diseases of the bladder accompanied with purulent secretion, in certain diseases of the brain, and sometimes in Bright's disease.

4thly. Urine not differing from the normal type occurs in slight non-febrile affections.

the blood bears an accurate and inseparable relation to the fever, there can be no doubt that the change in the constitution of the urine must be in relation to the same cause, for the urine is separated from the blood, and was previously an integral constituent of it; and because, further, every alteration in the constitution of the blood must involve corresponding changes in the secretions and excretions, and more especially in the urine. Since like effects follow like causes, and since in inflammatory affections the vascular system similarly participates in the disturbance, we may assume *à priori* that similar changes will occur in the urine,—a point confirmed by experience.

The urine discharged during inflammations is usually termed febrile urine. There is no objection to this term, since the cause of the change in the urine must be sought for in the fever: I shall, however, not introduce the term 'febrile urine' here, since it is more than probable that the changes in the composition of the urine vary according as the character of the fever is synochal or torpid. My analyses show, in fact, that the relative proportions of urea in fevers of a torpid and of a synochal character are different; and although the analyses are not yet sufficiently numerous to establish the difference with certainty, it still appears to me to be a point of sufficient importance to demand attention, and one that should be carefully worked out.

In order to take a correct view of the composition of the urine, we must bear in mind the composition of the blood, the reaction of the vascular system, and the diet, since the mixture of the proximate constituents is dependent upon these circumstances.

The following are the general characteristics of the urine in inflammatory affections: The urine is darker than usual, and is of a yellow, brown, or reddish-brown tint; it has an acid reaction, and is generally of a high specific gravity. With respect to its most important constituents, the urea is either absolutely increased, or is at the ordinary physiological average, or may be a little below it; the uric acid is always absolutely increased, and so are the extractive matters, especially the alcohol-extract. The salts are always absolutely diminished, especially the chloride of sodium; the sulphates, on the other hand, either approximate to the physiological average, or are not far below it. Assuming, as the mean of numerous analyses, that the urea

constitutes 39% of the solid residue of normal urine, I have found it as high as 46·8 in inflammatory affections. (In abdominal typhus, with a quick small pulse, I have seen it as low as 22.)

The physiological average of uric acid may be placed at 1·5% of the solid residue; in the phlogoses I have observed it amount to nearly 3%, and Becquerel even found it rise as high as 5·9%. The quantity of extractive matter &c., which in normal urine amounts to 23·5% of the solid residue, rises in inflammations to 43%. The fixed salts, which, in healthy urine, constitute about 25% of the solid residue, diminish here to 12%. The sulphate of potash, which, in healthy urine, forms about 10% of the solid residue, I found to vary in inflammation between 7% and 9%.

The composition of the urine becomes changed if much blood is abstracted during the progress of the inflammation. It becomes clearer, specifically lighter, and the amount of urea decreases absolutely and relatively.

At the height of the inflammation, or (perhaps it would be better to say) at the time when the fever puts on the synochal type most strongly, the urine is usually clear and deeply coloured; it subsequently forms a sediment of a yellow or red colour, composed of uric acid and urates.

Pericarditis.

I have had an opportunity of examining the urine in pericarditis. A man aged 36 years entered the hospital with the symptoms of very acute pericarditis; the pulse was 108, very full and hard. The urine obtained for analysis was clear, of a deep fiery-red colour, had an acid reaction, a specific gravity of 1023·5, and, on being heated, gave indications of the presence of albumen.

The chemical analysis gave:

	Analysis 98.	
Water	937·50	
Solid residue	62·50	
Urea	29·30	
Uric acid	1·50	
Extractive matters	22·70	
Earthy phosphates	0·55	7·4
Sulphate of potash	4·89	
Phosphate of soda	0·56	
Chloride of sodium and carbonate of soda	1·40	

A strict antiphlogistic regimen with bloodletting was ordered. The blood taken at the first venesection exhibited, after coagu-

lation, an inflammatory crust three fourths of an inch thick. At the fourth bleeding, when five pounds of blood had been abstracted, the inflammatory crust was one fourth of an inch thick, and the clot very firm. The urine now discharged (about thirty-six hours after the first bleeding) could hardly be considered darker than in health: it had an acid reaction, was devoid of albumen, and had a specific gravity of 1018. It was composed of the following constituents:

	Analysis 99.
Water	960·10
Solid residue	39·90
Urea	17·50
Uric acid	0·99
Extractive matters	15·10
Fixed salts	3·65

If we calculate the ratios of these constituents in relation to 100 parts of solid residue, and compare the numbers with the normal average, we shall detect in the first analysis the elements of a true inflammatory urine: the urea considerably exceeds the physiological average, the fixed salts collectively are diminished, while the sulphates are only a little below the normal standard, and the uric acid and extractive matters are increased. We see, at the same time, the effect produced upon the constitution of the urine by decided venesection.

100 parts of solid residue:

	In Analysis 98.	In Analysis 99.	In Normal Urine.
Urea	46·8	43·8	39·0
Uric acid	2·4	2·5	1·5
Extractive matters	36·2	37·8	23·5
Fixed salts	12·0	8·9	25·8
Sulphate of potash	7·8		10·3

[Zimmermann[1] found fibrin in the urine of a patient with "endocarditis of the right ventricle at the period of the commencement of hypertrophy." The urine was very variable in its characters, sometimes normal, sometimes sedimentary, and sometimes coagulable. In the latter case it was pale, and rapidly became alkaline.]

Phlebitis uterina.

I have had several opportunities of examining the urine in phlebitis uterina. In one instance occurring in our hospital I found it of a dark colour, an acid reaction, and depositing a

[1] Zur Analysis und Synthesis der pseudoplastischen Prozesse, p. 129.

slight sediment of urate of ammonia and uric acid. In another case (that of a woman aged 30), I likewise found it dark-coloured, but it had a slightly alkaline reaction with a disagreeable ammoniacal odour. It deposited a dirty yellow sediment, which appeared to the naked eye to be purulent, but which was shown by the microscope to consist of an immense number of mucus-granules, of a few crystals of ammoniaco-magnesian phosphate, and of an amorphous precipitate of phosphate of lime and urate of ammonia. The clear urine developed some carbonic acid on the addition of nitric acid, and became turbid, from which the presence of albumen was inferred.

Meningitis.

In the acute form of meningitis the urine assumes the inflammatory type. Schönlein describes it as being of a dark-red colour, very like brown beer. The secretion is usually scanty, (frequently only from eight to nine ounces in twenty-four hours,) it has a strong acid reaction, and the specific gravity and consequently the amount of solid residue is high. In four cases of meningitis observed by Becquerel, the mean specific gravity was 1025·2; sediments of uric acid sometimes occurred spontaneously, and were sometimes induced by the addition of nitric acid. In two of the cases he observed albumen. Schönlein observes that at the crisis towards recovery the urine is secreted more abundantly, and sometimes deposits purulent sediments.

Encephalitis.

The urine in encephalitis appears to be much the same as in meningitis. It sometimes deposits a sediment, and contains a small quantity of albumen. Becquerel found the specific gravity to be 1020·2.

[Considerable attention has recently been paid to the urine in the different forms of insanity. The most characteristic feature seems to be the excess of ammonia excreted as carbonate, urate, hydrochlorate, or ammoniaco-magnesian phosphate. The reader may consult Erlenmeyer,[1] Heinrich,[2] and Sutherland and Rigby,[3] on this subject.]

[1] Observationes physiolog.-patholog. in morotrophio Sigburgensi institut. de urina maniacorum.

[2] Ueber die Wichtigkeit mikroskopischer und chemischer Untersuchungen für die Psychiatrik, mit besondrer Rücksicht auf Harnsemiotik. (Häser's Archiv, vol. 7, 2.)

[3] Med. Gaz., June 1845.

Delirium tremens.

In delirium tremens the urine has more or less of the inflammatory type; sometimes, however, it resembles normal urine in its colour and reaction. In a man aged 40, who had a very severe attack, Becquerel found the urine acid for the first five days, with a mean specific gravity of 1017·2. It deposited a sediment either spontaneously or on the addition of nitric acid. In another man aged 40, who was also in the third stage of phthisis, and died three days afterwards, the urine possessed the characters of inflammation; it had a specific gravity of 1021·8, and deposited a sediment.

Myelitis.

In inflammation of the spinal cord the urine in many cases is much the same as in inflammation of the brain; it is red, acid, and sometimes thick and sedimentary. Becquerel, however, has observed cases of affections of the spinal cord in which the urine was not much removed from the normal type. In two persons aged 32 and 50 years respectively, who were suffering from a slight degree of paralysis of the lower extremities, the urine did not differ materially from the healthy secretion, although it varied on different days; it had an acid reaction, and contained a little more mucus than healthy urine.

In inflammatory affections of the brain, and still more in those of the spinal cord, especially in chronic cases, the kidneys and bladder sympathise in a high degree; the latter is sometimes paralysed. The character of the urine then changes in a very peculiar manner; it loses its acid reaction, and its colour becomes clearer; at the period of its excretion it is either slightly acid or neutral, and in a very short time it becomes alkaline, in consequence of the formation of carbonate of ammonia.

When first discharged, the urine is clear, generally of a bright yellow colour, and possesses rather an unpleasant odour. If allowed to stand, a glistening pellicle often forms very quickly on the surface, consisting partly of crystals of ammoniaco-magnesian phosphate, and partly of amorphous phosphate of lime, as may be seen by the microscope. The presence of ammonia may also be recognized at once by the odour, and by test-paper. After a time, the urine becomes turbid, and deposits a sediment

of earthy phosphates and mucus, which sometimes assumes a purulent appearance, and becomes tough and viscid in proportion to the quantity of mucus which is present. The odour is then strongly ammoniacal, and often stinking and putrescent; and on the addition of hydrochloric acid to the urine, a well-marked effervescence is produced by the liberation of carbonic acid. Cases have however been observed in which the urine was ammoniacal at the period of its emission from the bladder. A man aged about 40 years was brought into our hospital with a severe cerebral affection; he soon sank into a state of deep coma, and the urine was emitted involuntarily. On collecting the urine in a bottle, it had an unpleasant ammoniacal odour, an alkaline reaction, and soon deposited a sediment of mucus and earthy phosphates. Upon the addition of nitric acid after filtration, brisk effervescence took place, and the urine became turbid, in consequence of the presence of a slight quantity of albumen.

Becquerel observed much the same in four cases of chronic affection of the spinal cord, in which the functions of the bladder were impaired. The urine was discharged involuntarily, was of a dirty-yellow pale colour, of the ordinary specific gravity, and soon became alkaline; in those cases in which the urine was clearer, the specific gravity was lighter. The urine always contained a considerable quantity of mucus, muco-pus, or true pus, some albumen, ammoniaco-magnesian phosphate, phosphate of lime, and carbonate of lime.

In a former part of this work, attention has been directed to a peculiar arrangement which the elements of urea assume, when an aqueous solution of that substance is allowed to stand for a considerable period, or when it is treated with strong acids or alkalies. 1 atom of urea takes up 2 atoms of water, and becomes carbonate of ammonia, for

1 Atom of Urea . .	$H_4\ N_2\quad C_2\ O_2$
+ 2 Atoms of Water . .	$H_2\qquad O_2$
2 Atoms of Carb. Ammon. .	$H_6\ N_2 + C_2\ O_4 = 2\ (NH_3,\ CO_2)$

We have sufficient reason to justify the assumption that an arrangement of the elements of urea which occurs in pure water will also occur under certain circumstances in the kidneys or in the bladder, if the nervous activity, which has a very marked effect on the composition of the animal fluids, is changed, and if the urine contains mucus or muco-pus, which facilitate the

new arrangement of the atoms in the same manner as yeast resolves sugar into alcohol and carbonic acid.

Inflammatory affections of the brain and spinal cord are not the only diseases in which carbonate of ammonia is formed in the urine: I shall subsequently show that alkaline urine is frequently observed in diseases of the kidneys and the bladder, and in nervous fevers.

In inflammation of the respiratory organs the urine generally exhibits the inflammatory type in a high degree, varying, however, with the development, extent, and intensity of the disease.

Bronchitis.

In bronchitis, if the attack is severe, and accompanied with much synochal fever, the urine is scanty, of a dark-red colour, strongly acid, and of a high specific gravity.

Becquerel observed an appreciable amount of albumen in the urine in such cases. The urine deposited a sediment, and had a mean specific gravity of 1025·2. During convalescence, the urine either returns to the normal state, or assumes the anæmic type (of Becquerel), i. e., it is pale, of low specific gravity, and deficient in solid constituents, especially in urea. In milder forms of acute bronchitis Becquerel found the urine highly coloured, sometimes sedimentary, and of a mean specific gravity of 1024·3. In the mildest forms, the urine scarcely deviates from the normal state.

Pneumonia.

In pneumonia the urine is subject to considerable variations dependent upon the extent of the disease, and the degree of inflammation. In severe inflammations, the urine is very dark, of high specific gravity, and frequently sedimentary, especially at critical periods and during the fever; Becquerel, however, once found that the urine deposited a sediment on the day when the fever ceased. An appreciable amount of albumen is by no means rare. The urine remains acid during the whole period of inflammation, and Becquerel found the same to be the case during the period of convalescence also. The mucus is

increased during the febrile period, and this is observable in a more marked degree in women than in men.

Andral[1] has communicated some observations regarding the urinary sediments in pneumonia. Out of thirty-three cases, in twelve the urine remained perfectly clear throughout the whole course of the disease, and was not rendered turbid either by nitric acid or by heat; of these cases in six even the colour was not affected, and two sank under the disease. In nine of the thirty-three cases the urine was alternately clear and turbid or sedimentary. The sediments were for the most part spontaneous, and composed of amorphous uric acid. In one of these nine cases the urine contained albumen. The sediments occurred, as might be expected, in the different cases, at different periods and under different modifications. In one the urine was clear and of a reddish brown colour till the tenth day, and then formed for the first and only time a grayish white precipitate. In another case, the urine, which was of a brown-red colour, did not become turbid till the ninth day, when, as well as on the two following days, it formed a brick-red sediment. It then became clear, and remained so. In a third case, the urine, which was deep-coloured, deposited a grayish-red sediment on the seventh day, and then became clear and amber-coloured. In the other twelve cases that remain from the thirty-three, the urine was always turbid or sedimentary, either spontaneously or on the addition of a few drops of nitric acid, from the period of admission to the termination of the disease. Three of these twelve cases terminated fatally, and in these the urine remained turbid to the last. In the nine other cases the urine returned to its transparent state at the cessation of the disease.

Becquerel has arrived at the following results respecting the constitution of the urine in pneumonia.

In a case of acute pneumonia at the period of the crisis, the quantity of urine passed in twenty-four hours was 26 ounces, its specific gravity 1015·1, and its amount of solid residue 24·9 in 1000. The patient was depressed, his pulse 96, and the urine, as well as the skin, had a bilious tinge.

In a second case, in which there was intense fever, and the pulse was 120, 22 ounces of dark red urine of specific gravity

[1] Becquerel, Le Séméiotique des Urines, p. 332.

1021·8 were passed in twenty-four hours: there were 36 parts of solid residue in 1000 of urine. In a third case in which the patient had been much depressed by venesection and large doses of tartarized antimony, and where the pulse was 104, there were 30 ounces of dark-yellow, turbid, acid urine, of specific gravity 1015·9, and containing 26·3 of solid residue in 1000 parts, emitted in twenty-four hours.

Becquerel has made one complete analysis of the urine in a case of pneumonia in which the pulse was 100. He found

The quantity of urine in twenty-four hours	36 ounces
Specific gravity	1011·7
Water	980·6
Solid residue	19·4
Urea	7·3
Uric acid	0·4
Fixed salts	2·7
Extractive matters	8·8

I have made two analyses of urine passed in pneumonia. Analysis 100 represents the urine of a man aged 35 years; it was of a fiery-red colour, clear, and strongly acid; the pulse was full, 108 in the minute.

Analysis 101 represents the urine of a man aged 40 years; it was of a dark yellow colour, had an acid reaction, and contained a considerable quantity of mucus. In both cases there was a good deal of albumen.

	Analysis 100.		Analysis 101.
Specific gravity	1017·0		1020·0
Water	959·60		947·90
Solid residue	40·40		52·10
Urea	15·79		19·35
Uric acid	0·71		1·50
Alcohol-extract with lactic acid and ammonia-salts	9·34		9·65
Spirit-extract	1·10		3·18
Water-extract	5·84		6·40
Albumen	1·47		0·50
Earthy phosphates	0·42		0·56
Sulphate of potash	3·70	6·98	6·74
Phosphate of soda, chloride of sodium, and carbonate of soda	3·28		

If we calculate the amount of the more important constituents in relation to 100 parts of solid residue in these three analyses, we shall find that they exhibit very close approximations to each other, and on contrasting them with the normal standard, it will appear that the urea is a little diminished,

that the uric acid is increased, that the salts are diminished, and that the extractive matters, especially the alcohol-extract are increased in the urine of pneumonia.

	100 parts of solid residue of pneumonic urine contain: Becquerel.	Simon.		100 parts of solid residue of normal urine contain:
Urea	37·6	39·0	37·2	39·0
Uric acid	2·0	1·7	2·8	1·5
Fixed salts	14·0	18·3	14·0	25·8
Extractive matters	45·4	40·0	37·0	23·5
Sulphate of potash		9·0		10·3

According to Schönlein, the crisis in pneumonia shows itself in the urine by the secretion becoming turbid and sedimentary; after ten or twelve hours a crystalline micaceous deposit forms, above which the urine becomes clear.

The following instance is strongly confirmatory of Schönlein's opinion. In a case of pneumonia that recently occurred in his own wards, the urine, during the height of the inflammatory stage, was dark, very acid, and deposited no sediment; at the period of resolution it became paler and neutral; one morning I found it yellow, neutral, and with a sediment of white crystals visible even to the naked eye. The microscope at once revealed the beautiful shapes assumed by the ammoniaco-magnesian phosphate. I was much struck with the singular relations of the urine itself. It was perfectly neutral; and any acid, even dilute acetic, threw down a white precipitate, which led to the supposition that a caseous matter was present; I soon, however, found that this was not the case, for on treating a portion with hydrochloric acid and allowing it to stand for some time, very beautiful, nearly colourless crystals of uric acid were deposited.

Alcohol threw down a tolerably copious white precipitate, which was collected on a filter and washed with more alcohol. A portion of this precipitate was taken up by warm water, and left as a residue after evaporation; it was entirely consumed when heated on platinum foil; rubbed with caustic potash, it developed ammonia; warmed with nitric acid, it gave indications of the presence of a large amount of uric acid. The portion insoluble in warm water was readily soluble in hydrochloric acid, from which it could be again precipitated by ammonia, and on examining this precipitate under the microscope, I found that

it was composed of ammoniaco-magnesian phosphate. Hence it follows that the white precipitate which I at first mistook for casein, consisted of uric acid combined with ammonia, which existed dissolved in the urine to an unprecedented amount.

[Heller[1] has recorded a singular case in which the urine emitted an odour of hydrosulphate of ammonia, and deposited a sediment of urate of soda, during this disease.

The patient was a boy aged 14 years, with pneumonia of the right lung. The peculiar odour of the urine was first observed on the tenth day of the disease. The secretion on that day was copious, of a light-yellow colour, very turbid, and deposited an abundant clay-colour sediment. This sediment when examined under the microscope was found to consist of clear and beautifully defined large globules studded with numerous spines, mixed with smaller star-like objects of the same form. (See fig. 29 *a*.) There were also a few epithelium-scales and mucus-corpuscles. The urine had a strongly alkaline reaction: its specific gravity was 1018.

Heller noticed the following reactions:

1. Acetate of lead produced at once a very dark brown colour, and, finally, a blackish-brown precipitate of sulphuret of lead.

2. Perchloride of iron (which seems to be the best test for sulphuretted hydrogen in urine, since pure sulphuret of iron is thrown down, while the precipitate, caused by the former test, contains the chloride, &c.) rendered the secretion almost black.

3. Nitrate of silver showed that the chlorides were in great excess.

4. Nitrate of baryta indicated an abundance of sulphates.

5. Ammonia showed that the earthy phosphates were normal.

6. Nitric acid and heat indicated the existence of traces of albumen.

The urine contained in 1000 parts:

Water and hydrosulphate of ammonia	951·98
Solid constituents	48·02
Urea	12·21
Free uric acid	no trace
Albumen	traces
Urate of soda (in the sediment)	1·80
Extractive matters, with a large amount of hydrochlorate and carbonate of ammonia	27·40
Fixed salts	6·61

[1] Archiv für physiolog. und patholog. Chemie, vol. 1, 24.

As the fixed salts contained a mere trace of chloride of sodium, and nitrate of silver added to the urine showed that the chlorides were in excess, it is clear that nearly all the chlorine must be referred to the hydrochlorate of ammonia. That the sediment consisted of urate of soda was proved chemically as well as microscopically. The uric acid was determined by the ordinary test; and the soda by incinerating a portion in a platinum spoon, dissolving the white residue in dilute sulphuric acid, evaporating, and obtaining crystals of sulphate of soda.

On the following day, (the eleventh,) the odour remained nearly unchanged, but acetate of lead and perchloride of iron showed that the amount of hydrochlorate of ammonia was diminished. There was a small flocculent sediment composed of urate of ammonia, mucus, and fragments of epithelium, but entirely free from urate of soda. The urine now contained a normal amount of uric acid, and about as much albumen as on the preceding day.

On the twelfth day the peculiar odour was very faint, and on the thirteenth it altogether vanished. The urine was still alkaline, but gradually resumed its normal characters.

There was nothing in the treatment to account for the production of the sulphuretted hydrogen, and it can hardly be ascribed to the decomposition of the small quantity of albumen in the urine.

Zimmermann once detected fibrin in the urine of a patient with pneumonia on the third day. The secretion was of a fiery red colour, but deposited no sediment.]

Pleuritis.

In pleuritis the urine comports itself much the same way as in pneumonia. It exhibits, especially at the height of the inflammation, all the signs of inflammatory urine, and sometimes contains albumen.

In order to form a correct opinion regarding the urine in this disease, it is of especial importance to pay attention to the various circumstances that may modify the nature of the secretion, as for instance whether the disease is simple or complicated, acute or chronic, whether there is much or little fever, to what extent the inflammation has proceeded, and whether there is any effusion. Becquerel observed several instances of

pleuritis associated with pulmonary phthisis, and in fifteen out of seventeen cases observed by him, there was considerable effusion. In a man aged 36 years, with acute pleuritis, delirium, and certain typhoid symptoms, and whose pulse was 112 in the minute, the urine was of an orange-red colour, and on the addition of a drop of nitric acid, deposited a sediment of uric acid; it also contained a little albumen. The quantity of urine in twenty-four hours was 17 ounces, the specific gravity 1021, and in 1000 parts there were thirty-four of solid residue. In a man aged 23 years, who had sub-acute pleuritis, whose skin was slightly jaundiced, in whom there was slight anasarca of the lower extremities, (it being a case in which peritonitis was also suspected,) and who was much weakened by the free application of leeches, the urine was of a deep orange-colour and clear; on the addition of nitric acid it deposited an abundant sediment. In the course of twenty-four hours there were 26 ounces of urine passed, of specific gravity 1014·2.

1000 parts of urine contained:

Water	976·5
Solid residue	23·5
Urea	6·1
Uric acid	0·6
Fixed salts	6·4
Organic matters	10·2

Becquerel attributes the small amount of urea in this case to the debilitated state of the patient.

He found the mean specific gravity of the urine in seventeen cases of pleuritis to be 1021·8; in those cases in which there was a spontaneous sediment, it was 1024·8; and in those in which a sediment was produced by the addition of nitric acid, it was 1022·7. Albumen was present in three out of the seventeen cases. The amount of mucus was frequently increased, especially in the urine of women, but pus could never be detected.

Urine, which before the crisis is of a reddish colour, at that period deposits copious sediments.

[Zimmermann observed fibrin in the urine of a patient with pleuritis, from the third to the fifth day. The urine was of a dark yellow colour, and very frothy.]

Pleuropneumonia.

I have had an opportunity of observing a case in which urine of a very peculiar nature was emitted during pleuropneumonia.

The urine of a man of about 30 years of age, who was recovering from an attack of pleuropneumonia, and whose renal secretion had always previously been rather dark-coloured, became lighter and neutral. It was found one morning of a citron colour, and had deposited a white crystalline sediment, which, when observed under the microscope, was found to consist of beautifully-formed crystals of ammoniaco-magnesian phosphate, recognizable even by the naked eye, perfectly free from any mixture with phosphate of lime, urates, or mucus. The urine, which was filtered off, had a slight alkaline reaction, but did not become turbid on heating: the addition, however, of any acid, even acetic, produced a copious white turbidity, which did not disappear on the addition of an excess of the acid, but slowly vanished on the application of heat. In the acid urine thus cleared by heat ferrocyanide of potassium produced no effect. On evaporating the urine a sediment was deposited, and on mixing the residue with alcohol, a large quantity of a white substance was precipitated, which did not dissolve in water, and consisted of phosphate of magnesia, urate of ammonia, and a little extractive matter. Since the precipitate induced by the addition of acids to the urine gradually crystallized, and exhibited all the properties of uric acid, it is clear that the turbidity and precipitate had been caused by the decomposition of an urate which must have been present in a state of solution, to a very large amount. The urine had a specific gravity of 1022.

1000 parts were composed of:

	Analysis 102.	In 100 parts of of solid residue.
Water	951·10	
Solid constituents	48·90	
Urea	20·80	42·0
Uric acid[1]	1·48	3·0
Extractive matters	13·50	
Ammoniaco-magnesian phosphate and other fixed salts	10·20	

On the following day the properties of the urine were entirely changed. The colour certainly was the same, but it no longer had an alkaline reaction, nor did it form a crystalline sediment, nor was any turbidity induced by the addition of an acid. Free ammonia alone produced a slight cloudiness.

In a case of peripneumonia that recently occurred in Schönlein's

[1] The uric acid existed in the urine as urate of ammonia.

wards, the urine at the period of resolution exhibited precisely the same characters as in the above case, and as in the case of pneumonia noticed in page 217. There was a beautiful crystalline sediment of ammoniaco-magnesian phosphate, and any acid threw down a copious precipitate.

Cases such as these suggest two important questions, one of which may be readily answered by a series of careful observations: viz. whether these peculiar phenomena in the urine are connected with the process of resolution after inflammation of the respiratory organs?—and if so, what is the nature of the connexion?

The solution of the former question would afford material service in the prognosis of these affections. The phenomena persisted for three or four days, and in both cases recovery took place.

There was a man in Schönlein's wards with very extensive and intense peripneumonia, whose urine presented all the appearances of a saccharine fluid in which fermentation had been induced by yeast. It had a yellowish, turbid appearance, and its surface was covered by a thick layer of foam, in which numerous air-bubbles were developing themselves. Gas was likewise developed in the fluid itself, and in the amorphous yellow sediment that had been spontaneously deposited. The frothy covering and the sediment were composed of an amorphous matter, numerous crystals of ammoniaco-magnesian phosphate, and mucus-corpuscles. On treating the sediment with a free acid, the crystals and a portion of the amorphous matter (consisting of phosphate of lime) were dissolved: the remainder was insoluble, and resembled coagulated albumen in its behaviour towards reagents. The urine contained no trace of sugar, but a considerable amount of carbonate of ammonia.

On evaporating some of the filtered urine to which hydrochloric acid had been added, there remained a large quantity of hydrochlorate of ammonia. Very little urea was present, the greater part having been converted into carbonate of ammonia through the influence of the protein-compound. Vesical mucus exerts a similar action, and consequently in catarrh of the bladder the urine rapidly gives off a very disagreeable odour, and the amount of urea diminishes in proportion as the carbonate of ammonia increases.

Martin Solon[1] states, that in twenty-four cases of pleuropneumonia, he found albumen in twenty-two; it was especially observed at the period of the crisis.

Empyema.

It was known to the ancient physicians that effusions of pus into the thoracic cavity are, under certain circumstances and peculiar treatment, carried away by the kidneys.

Schönlein has observed several such instances, and I have had several opportunities, in the clinical wards of our hospital, of seeing cases of pleuritis with empyema, in which, after a proper course of treatment, turbid urine was discharged for some days. This urine contained albumen, and deposited a sediment, which, under the microscope and in its general physical relations resembled pus, or (in one case,) mucus mixed with pus.

The urine, which after some time became clear above the sediment, was of a dark colour, only slightly acid, and soon became alkaline. The symptoms of empyema gradually disappeared, in proportion as the urine continued to form purulent sediments.

Emphysema.

Becquerel has examined the urine in eight cases of pulmonary emphysema. When the emphysema produces violent dyspnœa, frequent cough and much general disturbance, the urine assumes the inflammatory type. Becquerel made one analysis of urine of this nature; it was of a dark brown colour, had an acid reaction, but deposited no sediment. Its specific gravity was 1016·8. It consisted of—

		In 100 parts of solid residue.
Water	972·3	
Solid residue	27·7	
Urea	13·0	47·0
Uric acid	0·4	1·4
Fixed salts	4·3	15·5
Organic matters	10·0	36·1

[1] Urinary Diseases and their Treatment. By Robert Willis, M.D. p. 157.

In a man aged 60 years, who had emphysema with bronchitis, the urine deposited a sediment, and had the high specific gravity of 1025·6. After he had taken purgatives for seven consecutive days, the urine became very aqueous and the specific gravity was only 1009·2. In two other cases in which emphysema was combined with cough and dyspnœa, the specific gravity was 1025·2 and 1022·2.

Angina tonsillaris.

In angina tonsillaris, when associated with synochal fever, the urine presents the inflammatory type. Becquerel observed a case in which the urine possessed the characteristics of inflammation in a high degree. It was red, and had the high specific gravity of 1029·7. In another case, which was combined with violent fever, the urine was dark-coloured, and had a specific gravity of 1023·9. In neither of these instances was there any sediment; but in the second case, on the seventeenth day, an abscess which had formed in one of the tonsils opened into the mouth, and on that day alone there was a spontaneous sediment of uric acid, and the specific gravity rose to 1025·2. In three other cases, in which the fever was not so high, the specific gravity remained lower.

Gastritis.

Becquerel has made some observations on the urine during gastritis, especially the chronic form.

Of three cases, two got worse, and merged into the acute form. The other case was unaccompanied by fever, and the urine did not appear to differ materially from the normal type. Of the two cases, one was that of a woman who was free from fever at the period of her admission into the hospital. The urine was pale and the specific gravity low. Continued fever subsequently came on, and assumed a typhoid character. The urine immediately became denser, darker in colour, and turbid (urina jumentosa). After some time the patient returned to her former state, and the urine again became clear. In the third case, that of a man aged 35 years, chronic gastritis suddenly merged into the subacute form; he had frequent bilious

vomiting and fever. The urine retained the inflammatory type until the condition of the patient improved. In a case of very acute gastritis with green watery vomiting, I found the urine scanty, of an extremely dark-red colour, acid, and forming a dull yellow sediment of urate of ammonia and uric acid: in fact, exhibiting all the characteristics of the urine of inflammation.

Enteritis and Dysentery.

In a severe case of enteritis, with obstinate constipation, violent pain on pressure, green acid vomitings, and wiry pulse, only a small quantity of urine was excreted. It was of a fiery-red colour, acid, and, after some time, threw down a copious reddish sediment of uric acid and urate of ammonia.

Becquerel has observed the urine in enteritis and dysentery: when the diarrhœa is only trifling, and unaccompanied by fever, there is hardly any deviation in the urine from the normal state. If, however, severe diarrhœa and fever are present, the urine may assume the inflammatory type. In a case of simple enteritis with diarrhœa the urine was at first very turbid, of specific gravity 1023·1, and deposited a sediment of uric acid: it was afterwards normal, and finally became anæmic, the specific gravity falling to 1010·0. In another case it was invariably high-coloured and very concentrated, its specific gravity being 1024·3; in this instance there was a daily sediment.

In eight cases of mild enteritis and diarrhœa, Becquerel only on one occasion detected a small quantity of albumen.

In two cases of a more chronic form of diarrhœa in persons who had long suffered from disease and from insufficient food, the urine was very light-coloured, and of low specific gravity, 1011·7.

According to Schönlein, in purely inflammatory diarrhœa, the urine is of a fiery-red colour, causes scalding in the urethra, and forms, at the crisis, a crystalline sediment of uric acid.

In catarrhal diarrhœa, the urine is rather dark, and becomes more so in the evening: at the crisis, a mucous sediment is deposited.

In bilious dysentery the urine is of a dark-red colour, tending to a brown; during the crisis it yields a fawn-coloured precipitate.

Finally, in typhous dysentery, the urine is dark, turbid, and fetid. During the crisis it forms no precipitate, but becomes clear and loses its smell.

Hepatitis.

Very different opinions have been expressed regarding the constitution of the urine in hepatitis.

Rose[1] asserts that, in several cases of acute and chronic hepatitis, he found the urea entirely absent. In the acute forms the urine was dark, in the chronic it was clear. It possessed no urinous smell, and the specific gravity was lower than that of healthy urine. Henry[2] found the urine, in a case of chronic inflammation of the liver, to be devoid of smell and colour, and of a specific gravity of only 1003. The extract obtained by evaporation gave no indications of urea on the addition of nitric acid. Rose puts the question, which can only be answered by farther analysis, whether the deficiency of urea arises from the actual inflammation of the liver, or from the dyspepsia that accompanies it. According to Coindet,[3] the urine, in inflammation of the liver, instead of urea, contains a substance resembling bilin.

The analyses made by Becquerel and myself of the urine in hepatitis do not correspond with these statements. I analysed the urine of a man aged 36 years, who was suffering from acute hepatitis. The urine was scanty, had an acid reaction, was of a dark reddish-brown colour, and deposited a copious red sediment of urate of ammonia and uric acid. On the addition of nitric acid the brown colour of the urine changed into a decided green. It likewise became turbid on the application of heat, so that it contained both biliphæin and a little albumen.

A quantitative analysis gave:

	Analysis 103.
Water	939·70
Solid constituents	60·30
Urea	22·50
Uric acid	1·70
Alcohol-extract	9·70
Water- and spirit-extracts and albumen	6·30
Earthy phosphates	0·84
Sulphate of potash	5·30
Phosphate of soda	3·13
Chloride of sodium and carbonate of soda	9·50

The urate of ammonia was not estimated in that form, but was reduced to uric acid by the addition of hydrochloric acid,

[1] Thomson's Annals of Philosophy, vol. 5, p. 423. [2] Ib. vol. 6, p. 392.
[3] Stark's Allg. Pathologie, p. 1152.

and weighed as such. The carbonate of soda associated with the chloride of sodium, arose from the reduction of the lactates.

Becquerel analysed the urine of a man (A) aged 33 years, who was attacked with icterus accompanied with fever and diarrhœa, after being in a violent rage. He was soon reduced to a state of great debility. The urine was very bilious, deposited a yellow sediment of uric acid, and had a specific gravity of 1013·0.

The urine of a woman (B) who had a chronic affection of the heart, and was attacked with acute hepatitis without very well-marked icterus, was of a deep yellow colour, but not tinged by bile. It deposited a spontaneous sediment, and had a specific gravity of 1018·9.

The composition of the urine in these two cases was as follows:

	A.	B.
Water . . .	978·50	968·90
Solid constituents . .	21·50	31·10
Urea . . .	6·15	13·10
Uric acid . .	1·14	1·57
Fixed salts . .	5·15	4·31
Organic matters . .	8·01	11·88

If we calculate the relative proportions of the various constituents in relation to one hundred parts of solid residue in these analyses, and compare them with the corresponding numbers in healthy urine, we find the proportions much the same as we have already found in pneumonia, except that in Becquerel's first case in which there was great debility accompanied with typhoid symptoms, the urea is very much diminished, whilst, in his second case, it is very much increased; in my case the salts were present to a large amount.

	100 parts of the solid residue of the urine in hepatitis contained			100 parts of the solid residue of healthy urine contained
	Becquerel. 1.	Becquerel. 2.	Simon.	
Urea .	29·6	42·2	37·5	39·0
Uric acid .	5·4	5·6	2·8	1·5
Fixed salts .	24·0	13·9	31·3	25·8
Extractive matters, &c.	41·1	38·2	26·6	23·5
Sulphates .			9·0	10·3

Schönlein states that the urine in hepatitis is of a dark-red colour, approaching a brown, that it usually contains biliphæin, and that at the crisis a rose-coloured precipitate is formed.

[Herzog[1] has recorded the case of a woman aged 44 years, in whom the principal symptoms were pain in the left lobe of the liver, and vomiting. The urine was of a saffron colour, but contained none of the ingredients of the bile. Its specific gravity was 1035·7, and 1000 parts yielded 68·84 of solid residue, 55·15% of which were urea.]

Peritonitis.

I have had one opportunity of analysing the urine in peritonitis puerperalis. It was passed by a woman aged 29 years, was of an acid reaction, and somewhat turbid, but not particularly dark: when examined with the microscope it was found to contain mucus-corpuscles, membranous shreds and other fragments, which could only be taken for epithelium composed of many regularly-formed, large, and elongated cells. On the application of heat the presence of a small quantity of albumen was detected. The specific gravity was 1020·0. The urine was composed of—

	Analysis 104.
Water	951·80
Solid constituents	48·20
Urea	20·10
Uric acid	0·83
Extractive matters	16·36
Fixed salts	9·20

By calculating the various constituents in relation to 100 parts of solid residue, we at once see that this urine is of a decidedly inflammatory type.

We obtain:

Urea	42·7
Uric acid	1·7
Fixed salts	19·1
Extractive matters	36·1

The urea even exceeds the physiological average, the salts are diminished, and the extractive matters increased.

[Scherer[2] analysed the urine in three cases of febris puerperalis. The urine was usually of a fiery-red colour, sometimes neutral, and often alkaline (or at least it rapidly became so;) it deposited a mixed sediment of pus, mucus, and urate of ammonia.

[1] Buchner's Repert. 1844.

[2] Untersuchungen, &c. p. 72.

Two analyses gave the following results:

	1.		2.
Water	956·63		960·24
Solid residue	46·37		39·76
Urea	10·00		12·42
Urate of ammonia	2·04		0·84
Alcohol-extract	12·54		9·34
Water-extract	8·40		10·23
Soluble salts	6·69		6·34
Earthy phosphates	0·80		0·62
Albumen and mucus	2·60	Mucus alone	0·54

In the third case the urine resembled butter-milk, and was loaded with urate of ammonia; it contained:

Water	937·00
Solid residue	63·00
Urea	6·70
Urate of ammonia	3·20
Alcohol-extract	19·02
Water-extract	27·20
Salts	6·31

Bouchardat[1] has published an analysis of milky urine passed by a woman with this disease. It contained no traces of sugar of milk or casein, the appearance being due to a large amount of urate of ammonia. It is moreover remarkable for the large quantity of fat and of albumen. It contained:

Water	940·9
Solid constituents	59·1
Urea	12·4
Uric acid	1·5
Albumen and mucus	29·2
Fat	2·5
Alcohol-extract with lactates, &c.	5·3
Alkaline sulphates	2·7
Phosphate of soda, and biphosphate of ammonia	4·2
Alkaline chlorides	0·8
Earthy phosphates	0·5

It must be observed that this urine was clear on emission, and only became turbid on cooling.]

Nysten[2] analysed the urine of a person aged 23 years, suffering from peritonitis. He found it of a dark-red colour, perfectly transparent, of the ordinary odour of urine, and of an acid reaction. An albuminous pellicle formed on the surface during evaporation, and the whole finally coagulated into a trembling gelatinous mass. Nysten states that this urine contained thrice the quantity of urea that "urina sanguinis" contains. The

[1] Journ. de Connaiss. Méd. Août 1843. [2] Recherches, &c. p. 240. 1811.

numbers which he gives do not, however, make out so large a ratio. I calculate from the figures quoted in Meckel's Archiv,[1] that Nysten's "urina sanguinis" contains 40 parts of solid residue, of which 12 are urea, in 1000 of urine, whilst on the other hand, in 1000 parts of his inflammatory urine there are 76 of solid residue, of which 22 are urea. The urine in the latter case was evidently much more concentrated than in the former, but the ratio of the urea to 100 parts of solid residue is the same in both, and coincides with my own analysis and those of Becquerel. It amounted to 30 parts of urea in 100 of solid residue.

Nephritis.

In nephritis acuta the urine is, according to Schönlein, of a dark red or claret colour, and contains hæmatin; according to Rayer the secretion is very scanty, especially when both kidneys are diseased: it contains a certain quantity of blood or albumen, and has an acid, a neutral, or even an alkaline reaction; it occasionally contains pus, as when an abscess communicates with the pelvis of the kidney, or when the nephritis is accompanied by inflammation of the mucous membrane of the urinary passages.

Becquerel analysed the urine in five cases of acute nephritis, and in none of them was blood present. The urine of a man who had acute nephritis possessed the properties of inflammatory urine, but contained neither pus, mucus, nor albumen, and deposited no sediment. In two cases accompanied with hectic fever, the urine assumed the inflammatory type, but contained no pus, and only, in one of the cases, a little albumen. In a woman who had, at the same time, disease of the heart, chronic gastritis, and incipient cirrhosis of the liver, the urine was highly inflammatory; it was acid, formed a copious uric-acid sediment, and contained some mucus and albumen. In a woman aged 23 years, who had an anæmic appearance, and was suffering from slight polydipsia, and in whom the symptoms of acute nephritis showed themselves by violent pain in the right kidney, by continual vomiting for above ten days, by great anxiety and some fever, Becquerel observed that the

[1] Vol. 2, p. 648.

urine remained quite unaffected; it was pale, clear, of low specific gravity, and very abundant. Willis directs attention to the sediment in simple nephritis, which distinguishes the disease from arthritic attacks; it usually consists of an amorphous powder of phosphate of lime with crystals of ammoniaco-magnesian phosphate, (if the urine is neutral or alkaline,) or of urates. If any crystals of uric acid are present, they are only in small quantity. In speaking of the urinary crisis at the commencement of recovery, Schönlein observes that the urine is secreted copiously and forms a creamy, and often a brown sediment, which afterwards separates itself into flocculent mucus; this mucous sediment will often go on for some weeks.

In nephritis arthritica the urine possesses very peculiar properties: Schönlein describes it as being of a fiery-red colour, very acid, and soon after emission depositing glistening red crystals of uric acid. In one instance Schönlein found that the sediment occupied half the volume of the urine. Sometimes the sediment is of a yellow colour, and occasionally there is gravel, mixed with mucus and blood. According to Willis, the urine in arthritic nephritis contains crystals of uric acid, even at the moment of its emission.

If the disease terminates in convalescence, Schönlein observes, that either copious sediments of a sandy micaceous appearance present themselves, or gravel of varying size is discharged with the urine.

In nephritis albuminosa, or Bright's granular degeneration of the kidneys, the urine differs materially from the normal type in always containing albumen; in other points, as for instance colour and composition, it may also be changed, or may more or less resemble normal urine.

During the first stage of the disease, hæmaturia sometimes occurs; I have witnessed a case of this sort in our hospital, and have analysed the urine, which was of a blood-red colour and contained blood-corpuscles but no fibrin. I subsequently analysed the blood of this patient. (See Analysis 37, Vol. I, p. 322.) The urine was neutral, and when allowed to stand, formed a sediment which was shown by the microscope to consist of blood-corpuscles.

On the application of heat, there was a considerable coagulation of albumen, which was tinged brown by hæmatin.

The specific gravity was 1017·0.

The analysis gave:

	Analysis 105.
Water	948·14
Solid residue	51·88
Urea	7·63
Albumen	15·00
Globulin	1·00
Hæmatin, extractive matter with salts, and hæmatoglobulin	23·80

I have in several cases made qualitative examinations of the urine in Bright's granular degeneration of the kidneys, and have always found it albuminous, usually pale, and of an acid or neutral reaction. The amount of albumen varies exceedingly.

Rayer,[1] who has long and accurately studied this disease, asserts that, in the acute form of the disorder, the urine is at first discharged scantily, that it is coloured red or brown by the presence of blood, that it has an acid reaction, and has usually a higher specific gravity than normal urine; when allowed to stand, fibrous-looking red flocculi of blood, (fibrin?) are precipitated which, when examined under the microscope, appear to consist of blood-corpuscles and mucus-granules mixed with epithelium. After some days the urine becomes of a citron-yellow colour, but upon the recurrence of the paroxysms the blood-red tint reappears, and disappears during the remissions. The amount of albumen discharged in twenty-four hours often fluctuates considerably. The amount of the other constituents, with the exception of the urea, does not seem to vary so much from the normal standard in the course of twenty-four hours in acute nephritis albuminosa as in the chronic form of the disease: the amount of urea is often only slightly decreased, and that of uric acid hardly at all, and consequently the specific gravity is not much affected.

In the chronic form of the disease, Rayer usually found the urine rather acid at the period of its discharge, but sometimes neutral or alkaline; it was always pale, often turbid, and at times had a curdy appearance from the presence of small white flocculi swimming in it, which, under the microscope, appeared as mi-

[1] Maladies des Reins.

nute whitish lamellæ, (epithelium?) frequently mixed with an amorphous mucous substance. Sometimes the turbidity arose from the presence of fat.

Rayer states that the amount of albumen is larger in chronic than in acute albuminous nephritis, while, on the contrary, the amorphous urates and the phosphates are diminished in the former affection. In the chronic form of this renal affection, before the commencement of dropsy, the ratio of the quantity of urine to the drink which has been taken, hardly differs at all from the normal proportion. This state may continue for several months, during which period the presence of albumen affords us a certain means of diagnosis.

Becquerel found the urine anæmic in the majority of his cases, (in sixteen out of twenty-two.) After the separation of the albumen, it appeared clear, pale, and of a greenish colour. Its specific gravity varied from 1006·3 to 1014·7. The mean specific gravity was 1011·3; sediments were not often observed, and the reaction was alkaline. The amount of urine differed very little from the normal quantity, and the relative proportions of the most important normal constituents to each other did not seem to be altered, but the urine was usually deficient in the amount of solid constituents.

In those cases in which Bright's disease was accompanied by other inflammatory attacks, by cardiac affections, by cirrhosis of the liver, or by pulmonary emphysema, Becquerel found the urine to possess the inflammatory type: it was of a dark colour, high specific gravity, an acid reaction, and not unfrequently deposited a sediment. Out of twenty-two cases of Bright's disease, Becquerel observed four in which the urine corresponded with the above description, and had a mean specific gravity of 1023·5. In two cases the urine was alkaline throughout the whole course of the disease, and deposited sediments composed of the phosphates of lime and magnesia, and carbonate of lime. The urine also contained in these cases a very large quantity of carbonic acid, which was combined with various bases (but chiefly with ammonia); the urea was at the same time considerably diminished, having yielded the elements for the formation of carbonate of ammonia. (See page 213.)

In some cases Becquerel found that the urine hardly differed at all in its physical characters from the normal type. He ob-

tained the following results from seven analyses. They are calculated for 1000 parts:

	1.	2.	3.	4.	5.	6.	7.
Specific gravity .	1016·3	1010·0	1007·5	1008·4	1005·4	1012·6	1010·0
Amount of urine in 24 hours, in ounces	28·0	35·2	62·0	78·0	106·0	25·3	
Water . . .	965·0	981·5	987·5	986·3	989·1	975·5	981·5
Solid constituents .	35·0	18·5	12·5	13·7	10·9	24·5	18·5
Urea . .	11·6	6·3	6·3	1·8	3·8	7·5	5·9
Uric acid . .	0·3	0·6	0·3	0·2	0·2	0·4	0·4
Albumen . .	11·9	2·5	0·1	3·4	2·6	5·9	
Fixed salts . .	6·6	4·1	2·5	2·9	1·7	4·9	3·7
Extractive matter	4·6	4·8	3·2	5·5	2·5	5·7	4·7

The urine in the 1st analysis was taken from a person suffering from Bright's disease without any complication. There was a little fever present. It was of a greenish yellow colour, very acid, and contained a little mucus. In the 2d analysis the urine belonged to a patient in whom the disease had assumed a chronic form; it was greenish, clear, and acid. In the 3d analysis the urine was taken from a person in a state of convalescence, and who afterwards recovered. The 4th analysis represents the urine of a man aged 35 years who was suffering from polydipsia, with œdema of the feet, and ascites. The urine was clear, alkaline, formed a diffuse, whitish sediment, and effervesced briskly on the addition of acids. The man from whom the urine of analysis 5 was obtained, had tubercles in the lungs and Bright's disease in the first stage. There was infiltration of the feet, and slight ascites; the urine was acid, pale, clear, and very abundant. The urine in the 6th analysis was taken from a man who also had tubercles in the lungs and Bright's disease in the first stage: there was no infiltration or dropsy: the urine was bloody and very acid.

If we compare these analyses of morbid urine with that of the healthy renal secretion, (the composition[1] of which is water 971·9, solid constituents 28·1, urea 12·1, uric acid 0·4, fixed salts 6·9, extractive matters 8·6,) we shall find that, with the exception of analysis 1, the solid constituents are less than in healthy urine, that the urea, with a single exception, only amounts to 1-3d or less of the solid constituents, whereas, according to Becquerel, it constitutes nearly one half in healthy

[1] It must be remembered that this is Becquerel's analysis of normal urine. See p. 145.

urine, that the quantities of fixed salts, and also of extractive matters, are likewise less than in the normal secretion; that, on the other hand, the morbid urine contains albumen, which is altogether absent in a state of health.

My own analyses give a similar result, at least as far as the urea is concerned. I have recently analysed the urine of a young man 21 years of age, suffering from Bright's disease, which was remarkable for the large quantity of albumen it contained. He had been attacked with anasarca and ascites, and the urinary secretion was diminished to about 12 ounces in twenty-four hours: the urine was of a dark-yellow colour, had an acid reaction, and formed a whitish mucous sediment, which, when examined under the microscope, appeared to consist, at least for the most part, of long, articulated tubes, similar to those of the confervæ, which were in part filled with a dark granular matter; there were, moreover, many globules filled with the same matter, which resembled Gluge's inflammatory globule; there were also mucus- or pus-granules, and in one instance a slight quantity of very beautifully-crystallized yellow uric acid. I have since examined the sediment in various cases of this disease, and find that this appearance is by no means uncommon. To the naked eye sediments of this nature resemble a little mucus, but on carefully pouring off the urine and examining the deposit under the microscope we observe:

1st. Mucus-corpuscles of the ordinary size, more or less granular, and decidedly nucleated. Fig. 31, *a. a.*

2dly. Pavement epithelium, from the mucous membrane of the bladder. Fig. 31, *b. b.*

3dly. Blood-corpuscles. Fig. 31, *c. c.*

4thly. Round dark vesicles apparently filled with granular matter, and varying in diameter from ·0006 to ·0009 of a French inch. They strongly resemble Gluge's inflammatory globule. Fig. 31, *d. d.*

5thly. Tubes composed of an amorphous matter, resembling coagulated albumen. Fig. 31, *e. e.* That these tubes have in most cases an actual capsule and are cylindrical may be seen by inclining the stage, when they will rotate in the fluid in which they are floating. In some the capsule appears to be absent, and we can then see an amorphous, finely granular mass, adhering in a cylindrical form. Some of these tubes are

full, others empty; the former contain a granular matter, darker at some points than others, and containing cells and vesicles, similar to mucus-corpuscles. The diameter of these tubes vary from ·0011 to ·0006 of a French inch.

I have satisfied myself, beyond a doubt, that they are derived from the epithelium investing the tubes of Bellini. Whether they are present as a consequence of Bright's disease, or whether they occur in other renal affections, must be decided by further observations: my present experience leads me to believe that they are cotemporaneous with a certain amount of albumen in the urine, but that blood-corpuscles need not necessarily be present with them. [These tubes occasionally present the twisted appearance represented in fig. 31, *f*, copied from Scherer. The diagnostic value of this form of sediment is uncertain; Schönlein regards it as an undoubted sign of Bright's disease; Scherer[1] has, however, observed it during the period of desquamation succeeding scarlatina; the same observation has been made of Lehmann, and I have myself observed it in various cases associated with a congested or irritated condition of the kidneys.]

On the fifth day from the commencement of treatment, the urine was much diminished in quantity; it amounted to only from 2 to 2¼ ounces in twenty-four hours, was of a dark-brown colour, continued to exhibit an acid reaction, and deposited a very copious sediment in relation to the small quantity of fluid. The quantity of albumen was so great that perfect coagulation took place on boiling some of the urine in a test-tube; the tube could be inverted without any fluid escaping. On the seventh day the amount of urine increased, and it subsequently became still more abundant; its properties remained much the same till the eleventh day, after which the albumen decreased to such an extent that on boiling a portion of the urine, only about half its volume became coagulated. The first occasion on which the urine was analysed, was when the secretion was reduced to a few ounces; the second occasion was on the day when it again became more abundant. In the latter case the solid constituents were much more abun-

[1] Untersuchungen, &c., p. 57.

dant, although the urine was clearer, and as much as 12 ounces was passed in the twenty-four hours.

The following are the results of the quantitative analyses:

	Analysis 106.	Analysis 107.
Specific gravity . .	1014·0	1022·0
Water . . .	966·10	933·50
Solid constituents . .	33·90	66·50
Urea . . .	4·77	10·10
Uric acid . . .	0·40	0·60
Fixed salts . . .	8·04	10·00
Extractive matters . .	2·40	
Albumen . . .	18·00	33·60

If we bring the quantities of urea and of albumen in these analyses in relation to 100 parts of solid constituents, we shall see that in both cases they occur in nearly equal ratios: for in the first we have 14% urea, and 54% albumen; and in the second 15% urea, and 51% albumen. The amount of urea is very much diminished; if we brought it in relation with the solid constituents exclusive of the albumen, it would even then be below the normal average, and would amount to only 30%.

The observations of Bright, Christison, and others, on the properties of the urine in this disease, correspond in general with the account which we have given.

[Some excellent cases of Bright's disease with chemical examinations of the urine, are given in the work of Scherer, to which we have already referred.

Dr. Percy has published a case of Bright's disease, and given an analysis of the urine. Its specific gravity was 1020.

In 1000 parts there were contained:

Water	946·82
Solid constituents	53·18
Urea	7·68
Uric acid and indeterminate animal matter .	17·52
Fixed soluble salts . . .	5·20
Earthy phosphates . . .	0·14
Albumen	22·64

Schlossberger has recently published a case in which, as the disease progressed, cerebral symptoms with maniacal paroxysms and perfect unconsciousness supervened, the paroxysms usually lasting for about twelve hours. The urine excreted before one of the paroxysms, and likewise that excreted during the first hour after the same paroxysm was submitted to analysis.

The urine, in both cases, was of a pale-yellow colour, faintly acid, somewhat turbid, and deposited a sediment of epithelium mixed with the tubes already described; in the course of eight hours there was also a considerable deposit of uric acid. The specific gravity of the former urine was 1011·6, and the secretion contained in 1000 parts:

	Before the paroxysm.	After the paroxysm.
Water	942·0	931·3
Solid residue	58·0	68·7
Urea	7·6	4·5
Uric acid with mucus	2·6	5·2
Alcohol-extract with salts	19·5	20·5
Water-extract with earthy phosphates	10·1	21·9
Albumen	17·9	17·0

In the second specimen there was a very large quantity of mucus.]

With respect to the analysis of very albuminous urine I must again refer to page 184, and I would expressly remark that the urine must be treated with absolute alcohol for the determination of the albumen and the urea, since we obtain inaccurate results in attempting to determine the urea from the evaporated solid residue. For the determination of the uric acid we must employ hydrochloric acid pretty freely diluted with water; it must be added carefully, in order not to precipitate any albumen. When blood occurs in the urine, we must adopt a precisely similar course.

Albuminous urine has now been so frequently observed in numerous diseased states of the organism independent of Bright's disease, that the idea has long been abandoned that granular degeneration of the kidneys always occurs when we have albuminous urine: the presence of albumen in the urine is, however, in no case a favorable symptom, and invariably indicates serious disease: I once, however, found a considerable quantity of albumen in the urine of a blooming and apparently quite healthy young man, and the only cause to which its presence could be assigned was that he had suffered from intermittent fever six years previously. There are various conditions under which this constituent may be present. During a catarrho-rheumatic affection I once observed a little albumen in my morning urine, but in the urine secreted in the middle of the same day not a trace

could be detected. I noticed the following case of albuminuria in Schönlein's wards. A man suffering from pneumonia passed very turbid urine till the period of incipient resolution; it had a very acid reaction, and after several hours' rest deposited no sediment. The turbidity arose from urate of ammonia in suspension, it disappeared on the application of heat, and again became apparent as the urine cooled. The urine presented this jumentous appearance for six days; on the seventh there was a slight flocculent amorphous deposit of urate of ammonia. On gently warming the urine the sediment perfectly dissolved, but at a boiling heat it became turbid from the separation of a considerable amount of albumen. On the following day the urine was very turbid in consequence of the presence of urate of ammonia, the amount of albumen remaining much the same. From that date the urine became clear, but remained albuminous till convalescence was established, the albumen gradually disappearing as the health improved. During the whole of this period the patient complained of no pain in the region of the kidney, even on strong pressure; neither was there any deposition of mucus.

A man treated antiphlogistically for a severe attack of articular rheumatism passed, for a considerable time, urine of a dark colour and very acid reaction, which, however, threw down no sediment. During the period of convalescence, when the swelling and pain had diminished, the urine became less acid, without any appearance of a sediment; the sweat, however, was still extremely acid, and one morning the urine contained a very considerable amount of albumen.

This abnormal constituent occurred in the whole of the urine excreted that day; on the morrow it was nearly gone, and on the third day had quite disappeared. No renal irritation could be detected, neither was any sediment observed.

The urine of a young man with all the signs of general dropsy contained a considerable amount of albumen, and deposited a light mucous sediment containing a considerable number of colourless blood-corpuscles (recognizable by their discoid form), numerous exudation-globules, mucus-corpuscles, and a few of the tubes described in page 235. The urine had the pale, green, opalescent appearance indicative of the presence

of albumen, and did not contain a trace of hæmatin, which must consequently have been perfectly separated from the blood-corpuscles before leaving the kidneys. The patient complained of no pain (even on pressure) in the lumbar region.

I received a specimen of urine from Dr. Broun, which had been passed by a patient who for a long time had suffered from considerable œdematous infiltration of the extremities. It gave no indication of albumen, neither did it contain any of the peculiar sediment which seems especially associated with renal irritation.

That in certain forms of dropsy the urine is albuminous, while in others not a trace of albumen can be detected, has been thoroughly demonstrated. In hydrothorax, and in dropsy dependent on disease of the heart or the liver, there is generally no albumen, whereas, if the dropsy arise from disease of the kidney, albumen is generally present. In Bright's disease, as far as my personal observations extend, it is always found, although the opposite opinion is held by Graves.[1]

Cystitis.

Two deviations from the normal condition are frequently observed in the urine in cases of cystitis; these are, its rapid tendency to alkalinity, in consequence of the formation of carbonate of ammonia, so that it is sometimes alkaline even at the period of emission; and the large amount of mucus or muco-pus. In the first stage of the disease the urine is, however, red, possesses all the characters of genuine inflammatory urine, and usually contains only a little mucus.

In cystitis acuta the urine was observed by Schönlein to be of a dark-red colour, and frequently to contain hæmatoglobulin. When the inflammation was caused by vesical calculi the urine had a pale greenish colour.

In a case of inflammation of the bladder, which was brought on by the use of stimulating injections, Becquerel found that the urine at first possessed the characters of the inflammatory type, but these in part disappeared in consequence of the quantity of the fluids drunk by the patient; it was acid, of average

[1] Dublin Journal, No. 60.

specific gravity, and deposited, after some time, a stratum of transparent mucus.

In another case in which the inflammation had been brought on in a similar way, the urine was alkaline, had a specific gravity of 1022·6, deposited a thick layer of purulent mucus, contained albumen and some fat which was removable by ether, and exhibited pus-corpuscles under the microscope.

In a third case of acute cystitis, which speedily came to a fatal termination, Becquerel found the urine, at the period of its discharge, turbid, thick, and viscid. On allowing it to stand for some time, there was formed a layer which occupied nearly the lower half of the vessel, and consisted of almost pure and white pus: the fluid above the sediment was pale, clear, and alkaline.

As the disease terminates in convalescence copious sediments are deposited, or, if a sediment had been formed during the height of the disease, it is now more abundant.

In arthritic cases the sediment is, according to Schönlein, of a crystalline micaceous appearance; in non-arthritic cases (and in the latter stage, in arthritic cases also,) very bulky mucous sediments occur, which are often tough and fibrous, from the action of carbonate of ammonia. Sediments of this latter form frequently continue for a long time, so as to constitute genuine catarrhus vesicæ. Schönlein states, that in cystitis erysipelacea the urine is of a dark reddish-brown colour, mixed with fibrous, flocculent, or bran-like mucus.

Metritis.

In acute metritis the urine possesses all the characters of the inflammatory type. Becquerel found it acid, of a reddish colour, of average specific gravity (1018·0—1021·0), and sometimes containing albumen. A sediment of uric acid was always thrown down either spontaneously or by the addition of nitric acid: during convalescence it became paler and less dense, and ceased to deposit sediments. The leucorrhœa which accompanies metritis, or appears towards the period of convalescence, renders the urine turbid and cloudy.

In chronic metritis, and in uterine congestion, the urine is much the same, except that the inflammatory signs are less

marked. In these cases, especially in chronic metritis, it is frequently mixed with the leucorrhœal uterine discharge.

[In a case of endometritis[1] and pericarditis with purulent exudation, occurring thirteen days after delivery, the urine was passed in very small quantity, evolved a disagreeable odour, was turbid, and deposited a rather copious sediment. The sediment consisted for the most part of pus, mixed with a few blood-corpuscles, epithelium-scales, and fat-vesicles.

The reaction of the urine was acid; its specific gravity 1020. It appeared on analysis that the urea was much diminished, that there were only traces of uric acid, that there was a little albumen, no bile-pigment, and scarcely any trace of chlorides. The sulphates were slightly, and the earthy-phosphates much increased.]

Urine in typhus.

We formerly had occasion to remark that less was known of the actual condition of the blood in typhus than in inflammatory diseases; the same observation is equally true with regard to the urine. Very little light has yet been thrown upon the varying nature of the urine in this disease: sometimes we find it of a brown colour, acid, and of high specific gravity, in fact, like inflammatory urine; sometimes it is clear like the urine after copious drinking; on other occasions it does not appear to differ from normal urine: it varies between an acid, an alkaline, and a neutral reaction. It is to be presumed that these changes in the relative constitution of the urine correspond with certain reactions in the organism; the connexion, however, is not always very clear, even to the observant physician. This much is, however, certain, that in the first stage of the disease a dark, specifically dense, acid urine is often excreted, and that in proportion as the fever assumes a torpid character, and the vital powers become depressed, the urine becomes clearer, loses its acidity, becomes neutral, and in a very short time (often after one to two hours) alkaline, containing carbonate of ammonia. Sometimes a yellowish-brown, turbid, fetid, and alkaline urine is excreted.

[1] Heller's Archiv, vol. 1, p. 23.

The difference between the urine in typhus and in inflammatory disorders is sufficiently great to be determined with certainty. In the phlogoses when the fever assumes a synochal character, we observe that the urine, with some few exceptions (as occasionally in cases of injury of the spinal cord, and in diseases of the kidneys and bladder,) is of a red colour, acid, usually clear, and only forms sediments of a yellow, red, or brown colour, and consisting of uric acid and the urates, on the occurrence of a crisis; the quantity of the urine is diminished, and the specific gravity increased; the urea is either absolutely increased, or is equal to, or very little below the physiological average; the quantity of salts is in general diminished, (the sulphates, however, in a much less proportion than the chlorides;) and the quantity of extractive matter increased.

In typhus the quantity of urine is decreased; it varies extremely in colour and reaction; the red tint of inflammatory urine is, however, very seldom observed, but more commonly a brown or reddish-brown colour; the more the fever assumes the erethismic character or approximates to the synochal form in consequence of being complicated with inflammation of the respiratory organs, the more also does the urine approximate in its physical characters to the inflammatory type; and in proportion to the torpid character of the fever and to the prolapsus virium, does the urine become less dense and acid, and the more readily does it assume the alkaline state.

The urine may resemble the normal type as far as the specific gravity and the amount of solid constituents are concerned; it is usually, however, less dense, and it frequently happens that the deeply-coloured urine of typhus has a much lower specific gravity than we should have been led, from its tint, to expect. The amount of urea never reaches the physiological mean, and is often far below it; the uric acid, on the other hand, is often increased, especially on the occurrence of the urinary crisis. The salts, including the sulphates, are very much diminished, so that sometimes hardly a trace of them can be detected. We have seen that in the phlogoses the urea ordinarily attains the physiological average of 39% of the solid residue, and that it sometimes even exceeds it; while in the urine of typhus I found that the maximum proportion of urea amounted to only 31·8%, the minimum to 22%, and the mean of 7 analyses to 26·6% of the

solid residue. Hence it would appear that this decided decrease of the urea below the physiological average is a characteristic peculiarity of the urine in typhus. I found the maximum proportion of uric acid amount to 4·8%, and the minimum to 0·9% of the solid residue; and with respect to the fixed salts, the maximum was 13%, and the minimum 3·4% of the solid residue.

With regard to the state of the urine in typhus, and especially in abdominal typhus, Schönlein observes that it is altogether inconstant, that it is sometimes pale, sometimes apparently normal, and sometimes jumentous. In the first stage it is usually of a dark brownish-red colour, tolerably clear in the sthenic form of fever, but darker in the erethismic and very torpid forms.

A turbidity in the urine, together with other symptoms of a crisis, frequently indicates the transition into the second stage.

In this nervous stage of the disease the urine is of a dark brown colour, and very acid. A perturbation is observed in the urine on the seventeenth day, (occasionally it occurs on the eleventh or twelfth day), and at the period of the actual crisis, (the fourteenth or twenty-first day,) the urine becomes clearer and more abundant; sediments also occur, not of a crystalline form, as in the phlogoses, but of a diffuse, flocculent, mucous nature: the urine sometimes becomes as clear as the *urina spastica.*

If the typhus disappears prematurely on the fourth or seventh day, we frequently observe, in addition to other acute critical symptoms, a discharge of turbid, and often purulent urine. In the form to which the term 'febris nervosa putrida' has been applied, when the decomposition of the blood is particularly striking, we meet with blood in the urine, which becomes very quickly decomposed, and is of a dark brown or blackish colour. Convalescence after typhus can never be considered as safely established until the urine becomes perfectly yellow and pale. As long as it remains of a dark brown, or even high colour, there is still danger. The more brown, decomposed, and fetid the urine is during the course of the typhus fever, the more unfavorable is the prognosis.

In petechial typhus during the first stage, the urine is not very highly coloured; on the seventh day there is frequently a turbidity; during the nervous stage the urine is of a dark brown

colour; and at the period of the crisis, sediments are also deposited.

Willis[1] remarks, that the state of the urine in typhoid fevers, especially in regard to its acid or alkaline reaction, may be studied with advantage, as affording an indication of the progress of the disease. During the early stage it is acid; as the disease advances, it becomes neutral, and then alkaline; as the disease decreases it again becomes neutral, and ultimately acid. The return to the acid state is always a good symptom, and will sometimes enable us to offer a favorable prognosis.

The observations made by Pelletan in Bouillaud's clinique, perfectly coincide with the above statements; he observes that, during the first days of typhus, the urine is of a dirty yellow colour, and transparent; during the whole of the first stage it is always more or less acid, and the darkest kind, which has an odour like gingerbread, is usually the most acid. At a later period it changes, resembles turbid whey or putrid broth, and is usually neutral; it is also sometimes found of a dark colour, with an odour like cow-dung. At a still later period, it is turbid, putrid, and smells rather ammoniacal, assuming at the same time a corresponding reaction. If the disease takes a favorable turn from this period, the urine goes through the same changes in a reversed order.

The observations which I have made in Schönlein's clinical ward correspond entirely with those already communicated.

In two men aged between 20 and 30 years, who had very severe attacks, I observed that the urine became alkaline towards the seventeenth and twenty-fourth days of the disease: it was then discharged in greater quantity than before, and was clearer; it was pale, somewhat turbid, and soon deposited a dirty or a bright-red sediment composed of earthy phosphates, urate of ammonia, and mucus. Test-paper and a rod moistened in hydrochloric acid, afforded indications of ammonia, and by the addition of an acid the presence of carbonic acid, but not of albumen, was demonstrated. Both men recovered, but convalescence, especially in one of them, was very slow. The urine then became gradually clear, yellow, and acid, as before: the period

[1] Urinary Diseases and their Treatment, p. 128.

during which, in one of these cases, the urine continued uninterruptedly alkaline, was above eight days.

In another case, in which I followed the variations of the urine through the course of the disease, it became alkaline at noon on the third seventh-day period, but the next day it again became acid, and remained so till death, which soon occurred.

[Schönlein's opinion that the urine in the regular course of typhus is at first dark and very acid, subsequently neutral and even alkaline, and finally again becomes acid at the commencement of convalescence, has received further confirmation from the following observations quoted by Simon in his 'Beiträge.'

In one case the urine became faintly alkaline on the seventh day after admission; it remained either alkaline or neutral for seven or eight days; and then became faintly acid and gradually clearer, as soon as the patient exhibited symptoms of convalescence.

In a second (very severe) case the urine remained acid till the twenty-first day; it then became neutral, and afterwards alkaline, for the space of ten or eleven days, when it returned to its normal reaction.

In two other cases the urine became alkaline previously to the fourteenth day of the disease; in one of them the secretion was so thoroughly saturated with carbonate of ammonia, and evolved so disgusting an odour as to be perceptible over the whole ward. This urine deposited a considerable sediment of pus or mucus, mixed with the phosphates of lime and magnesia, and effervesced briskly on the addition of an acid. In one of these cases the urine remained alkaline for fourteen, and in the other, for twenty-one days, before it resumed its acid reaction. Both cases recovered.

It is worthy of notice, that a deposition of urate of ammonia not unfrequently precedes the occurrence of alkalinity and the appearance of the earthy phosphates, which, as Schönlein remarks, may be regarded as the precursors of a favorable change.

During the mild form of typhus recently (1843) prevalent in Berlin, he noticed these changes in several cases, and in fact, when from being alkaline the urine again became acid, and at

the same time clear and abundant, there was scarcely any risk in giving a favorable prognosis.]

In some cases in which the patients recovered, the dark urine did not become alkaline quickly enough to be perceived during the hospital-visit, but by the evening it would deposit a considerable dirty viscid sediment composed of earthy phosphates and mucus, and would have a well-marked alkaline reaction: subsequently it retained its acidity for a longer period, until at length it resumed its normal condition. On the other hand, I observed one case in which the urine was dark, had an acid reaction, and only became slightly alkaline for a short time before death; it continued throughout of this dark colour, was turbid, and threw down a mucous sediment. In another case the urine, which was of a dark, muddy colour, remained acid till death.

Lastly, I will refer to two cases of typhus in girls, where the urine continued of a dark colour, and exhibited an acid reaction, throughout the course of the disease, which lasted from three to four weeks. During convalescence it became turbid, and deposited an imperfect sediment; although it did not entirely lose its acid reaction, it now became sooner ammoniacal than before.

In a child the urine was clear and almost amber-coloured; it became, however, quickly alkaline, and deposited a viscid, white sediment of earthy-phosphates. Dark acid urine I have frequently found to be slightly albuminous. From these observations, as well as from those of Willis, Pelletan, and others, we arrive at the conclusion that in a regular and favorable case of typhus the urine loses its acid and assumes an alkaline reaction; that it then again becomes gradually acid, although not perhaps in the exact reverse proportion, and that it does not necessarily reassume the dirty-brown colour which it possessed during the first period: consequently the transition of the urine in typhus from the acid to the alkaline condition need not be so much dreaded as has been generally supposed.

I cannot positively assert that the urine in typhus is alkaline at the moment of its emission from the bladder. Becquerel expresses himself opposed to the idea; he considers that alka-

line urine is only passed in those cases in which it has remained for a very long time in the bladder. I shall now give the facts which he has collected regarding the urine in typhoid fever. He observed the urine in thirty-eight cases of abdominal typhus, eleven of which were very severe, eighteen of ordinary intensity, and nine were mild cases. Purgatives, especially Seidlitz waters, formed the basis of the general treatment. Seven of the eleven severe cases recovered; two, however, subsequently died from tubercular phthisis. Of the four fatal cases, one died on the eighth day, the second at a more advanced period, the third on the fifty-third day, and the fourth from perforation of the intestines.

In all these cases Becquerel found the urine to deviate considerably from the normal type. While the fever was intense, and before the adynamic period was established, the urine was scanty, highly coloured, dense, and charged with uric acid; it sometimes contained blood, albumen, or mucus in considerable quantity, but seldom pus. In many cases, it exhibited a more marked tendency to decomposition than is observed in other diseases, and the rapidity and facility of this spontaneous decomposition usually corresponded with the severity of the disease. But when, in the progress of the disease, the adynamic period comes on, the quantity of the urine will be diminished in consequence of the intensity of the fever, the colour will be high but the specific gravity low, and at the same time there will be frequent deposits of uric acid either spontaneous or after the addition of an acid, or else the urine will assume the anæmic type and be pale, of low specific gravity, and only slightly acid. The urine of this latter form differs widely from that which was passed at an earlier period of the disease, and is diagnostic of the asthenic state and of its degree of intensity. But exceptions to this general rule have been observed both by Becquerel and myself; on the one hand, the urine has been slightly coloured, clear, and of low specific gravity in cases of typhoid fever in which the patients were far removed from the asthenic state, and on the other hand the latter state (the asthenic) is not incompatible with turbid, sedimentary urine.

We must not overlook the circumstance of the urine having possibly remained for a long time in the bladder, in which case

it may undergo decomposition there, and by its irritative action on the vesical mucous membrane produce an excessive secretion of mucus or even pus.

Becquerel found that the density of the urine, except in those cases in which there was great prostration of strength, was above that of normal urine, and amounted on an average to 1023·5. This, as I have already observed, is opposed to my own observations. The mean specific gravity of the urine which threw down a spontaneous sediment was, according to Becquerel, 1024·7. The colour of the urine increased with the concentration. The colour of the spontaneous sediments in some cases resembled the brick-dust tint of the sedimentum latericium; the precipitates thrown down by acids were usually of a yellowish or gray colour.

In the thirty-eight cases of typhus observed by Becquerel, pus occurred in the urine of only one individual, and in this case the secretion was alkaline; in all the others it was acid. In a very extensive series of observations made by Andral the urine was found to have an acid reaction, except in the following cases, viz. when pus was present, when the urine had remained for a long time in the bladder, when the patient had taken a great quantity of alkaline fluids, or, lastly, when the secretion was not examined for some hours after its discharge.

The precipitate which Becquerel observed in the urine of typhus, whether thrown down spontaneously or after the addition of an acid, consisted of amorphous or crystalline uric acid; the latter was only seen twice, once after the addition of a little nitric acid, and in the other instance forming a portion of a spontaneous sediment. These spontaneous deposits were usually of a gray or reddish colour.

The important questions, whether urinary sediments in typhus occur at any fixed epochs of the disease?—whether there is any connexion between their appearance and a favorable result?—and whether their presence is prognostic of such a result?—are answered by Becquerel in the negative.

From a table communicated by Becquerel it appears that some persons died in whom the urine deposited a sediment either spontaneously or on the addition of an acid, almost uninterruptedly from the fifth or seventh day; while others, under similar circumstances, recovered: in a case, in which the

urine threw down a sediment spontaneously on the third day of the fever, and after the addition of an acid on the eleventh, twelfth, and thirteenth days, death occurred on the fifteenth day; in other cases, in which sediments appeared at intervals, convalescence took place. Out of twenty-seven observations, a sediment first occurred in one case on the third day of the disease (death); in one case on the fifth day (death); in one on the sixth (recovery); in three on the seventh (two deaths, one recovery); in one on the eighth (recovery); in four on the ninth (recovery); in five on the tenth (recovery); in four on the eleventh (recovery); in three on the twelfth (recovery): in four cases the sediment first appeared after the twelfth day (recovery).

Amongst Becquerel's thirty-eight cases, he only found blood in the urine in two cases: in one the patient was dangerously ill, and a small quantity of blood was found in the urine every morning; in the other, the patient was recovering from fever when he was attacked with small-pox. Albumen was found in eight cases, in which neither pus nor blood was present. Of these eight cases, four had the fever very severely, three moderately, and one slightly. Of the severe cases, two terminated in death; in one of these albumen was only found during the last eight days; in the other it occurred first on the twenty-fourth or twenty-fifth day, and subsequently from the thirty-first to the thirty-eighth day, when death took place. In the other cases the albumen only appeared at intervals.

Andral examined the urine in forty-one cases of abdominal typhus, of which seven died. They were all treated by copious bloodletting. In eleven out of the thirty-four who recovered the urine did not differ in appearance from the normal type, and nitric acid threw down no precipitate. In the other twenty-three cases, the urine was generally deeply coloured, (of a reddish tinge,) and became turbid either spontaneously or after the addition of nitric acid. In some cases it remained turbid throughout the whole course of the disease; in others it presented no turbidity at first, even after the addition of nitric acid; but as the febrile symptoms attained their greatest height, it became clouded, and as they disappeared, it gradually regained its original appearance. In other cases the appearances of the urine possessed no regularity, and it was clear and turbid or sedimentary by turns.

The urine during the convalescence of the thirty-four cases, was usually pale and transparent; but in some it remained turbid or sedimentary for a considerable time after the termination of the fever. Albumen was only observed in one instance.

In these thirty-four cases the urine was acid during the whole course of the disease, and remained so during convalescence, except in two cases, in which it was invariably strongly alkaline, light, watery, pale, and transparent; the persons from whom the urine, in these cases, was derived, were very weak, and in a state of well-marked anæmia, having had the fever very severely, and having been repeatedly bled. The urine in these cases did not appear to have been retained in the bladder longer than usual. After several days, it became neutral; it then became gradually more deeply coloured, and ultimately regained its acid reaction.

With respect to the seven fatal cases, the urine in one retained its normal appearance; in four it assumed from the commencement till death a deep colour, and became turbid from an excess of uric acid which deposited itself; and in all the seven was invariably acid.

I shall now communicate the results of my own analyses of the urine in typhus, which enter more into minutiæ.

I have made several analyses of the urine in abdominal typhus, but have only determined with accuracy the most important of the constituents.

The urine in analysis 108 was taken from a man aged 30 years, who had been dangerously ill for three weeks; delirium, subsultus tendinum, pulse frequent and small; the urine was moderately dark, turbid without a sediment, and strongly acid. He died two days afterwards. It is worthy of remark that the urine had on one occasion, about eight days before death, an alkaline reaction; it returned to its acid condition the following day. Analysis 109 represents the urine of a typhus patient, who was lying in a state of deep coma; it was pale, and had an acid reaction. Analysis 110 represents the urine of the same patient three days afterwards, when he was in a state of great general debility; it was pale, transparent, and slightly acid, but after some time became alkaline, and deposited a sediment of earthy phosphates. The patient subse-

quently recovered after a tedious convalescence. Analysis 111 represents the urine of a typhus patient on the eighteenth day of the disease; it was dark, tolerably clear, threw down no sediment, and had an acid reaction. The urine in analysis 112 belonged to a person who had been suffering from typhus for some weeks; delirium, subsultus tendinum, stupor, rapid and very small pulse; it was brown, turbid, of an unpleasant odour (like the urine of horses), slightly alkaline, and deposited in a short time a very copious, flocculent, reddish sediment of urate of ammonia. Analysis 113 represents the urine of a girl suffering severely from typhus, who lay in a state of great prostration and coma, and afterwards died; it was of a dark brown colour, slightly alkaline, rather turbid, and without a sediment; a deposit of earthy phosphates was, however, subsequently formed. Analysis 114 represents the urine of a girl who had had typhus for four weeks: coma, subsultus tendinum, pulse 120 and small. It was rather dark, was turbid, and had an alkaline reaction and ammoniacal odour. The urine in analysis 115 was taken from the same girl two days afterwards: her general condition much as before, pulse 112, urine neutral, of a yellowish-brown colour and rather turbid. Analysis 116 represents the urine of a girl aged 20 years, in whom the fever was less severe than in the previous case: there were symptoms of bronchitis, pulse as high as 108, urine of a yellowish-brown colour, and slightly acid. The urine in analysis 117 was passed by a man aged 30 years, who had been ill fourteen days. Coma; pulse 108, and small.

	Anal. 108.	Anal. 109.	Anal. 110.	Anal. 111.	Anal. 112.
Specific gravity	1016·00	1010·00	1009·00	1017·00	1016·00
Water	960·00	971·00	975·00	950·00	953·50
Solid constituents	40·00	29·00	25·00	50·00	46·50
Urea	9·47	7·30	6·70	—	10·50
Uric acid	1·10	0·62	0·40	—	1·50
Earthy phosphates	—	trace	trace	—	trace
Sulphate of potash	—	trace	trace	—	—
Sum of fixed salts	2·50	1·00	1·00	6·50	5·20

	Anal. 113.	Anal. 114.	Anal. 115.	Anal. 116.	Anal. 117.
Specific gravity	1015·00	1016·00	1013·50	1018·00	1026·00
Water	958·40	952·80	956·80	941·50	930·00
Solid constituents	41·60	47·20	43·20	58·50	70·00
Urea	9·30	13·20	12·60	18·60	22·50
Uric acid	0·40	1·50	2·10	0·92	1·47
Earthy phosphates	—	—	trace	—	0·90
Sulphate of potash	—	—	0·64	—	—
Sum of fixed salts	—	—	2·76	2·80	2·90

If we calculate the ratios of these constituents to 100 parts of solid residue, and compare them with the average ratios in normal urine, we shall arrive at the results noticed in page 343, viz. that in the urine in typhus the urea falls below the physiological average, the uric acid is increased, and the fixed salts are much diminished.

	In 100 parts of the solid residue of the urine in typhus, there are contained: Analyses									100 parts of the solid residue of normal urine contain
	108.	109.	110.	112.	113.	114.	115.	116.	117.	
Urea	23·6	25·0	26·8	22·6	22·0	28·7	31·2	31·8	32·3	39·0
Uric acid	2·7	2·1	1·6	3·2	0·9	3·2	4·8	1·6	2·1	1·5
Fixed salts	6·0	3·4	4·0	11·1	—	—	6·3	4·8	4·1	25·8

[Scherer[1] has made several analyses of the urine in typhus, which differ in some points from those of Simon. He observes that, in many cases, the urine is tolerably abundant in lactic acid and extractive matters, and continues so throughout the case, whether it terminate fatally or not. In a few cases the urine was alkaline, and this generally occurred when the fever assumed a very low or putrid form, or when the contents of the bladder had not been discharged for some time; and that not unfrequently, after being acid, it became alkaline, and then again acid. In the most severe cases it usually contained a little albumen.

The urea was never increased except in those cases in which the secretion was much diminished, and was often much below the normal standard. As a general rule, the fixed salts were considerably diminished, and the ammonia-salts increased. There was always an excess of uric acid, which usually separated, after standing, in the form of small red crystals, on the sides of the vessel; this was especially observed when there was much pulmonary congestion. No critical phenomena indicated the commencement of reconvalescence. Scherer has published the following analyses:

1. A woman aged 38 years, with slow nervous fever. The urine on the ninth day contained, in 1000 parts:—

[1] Untersuchungen, &c. p. 65.

Water	945·48
Solid constituents	54·52
Urea	8·60
Uric acid	0·60
Alcohol-extract with lactic acid and lactates	27·50
Water-extract	7·40
Albumen	1·80
Fixed salts soluble in water	6·20
Earthy phosphates	2·30

On the 12th day of the disease it contained:

Water	951·26
Solid constituents	48·74
Urea	10·40
Uric acid	0·70
Alcohol-extract with lactic acid and lactates	21·80
Water-extract with ammonia-salts	7·90
Albumen	1·00
Fixed salts soluble in water	5·30
Earthy phosphates	1·20

On the 15th day it contained:

Water	959·29
Solid constituents	40·71
Urea	11·40
Uric acid	0·80
Alcohol-extract with lactic acid and lactates	15·70
Water-extract	6·20
Albumen and mucus	0·90
Fixed salts soluble in water	4·50
Earthy phosphates	0·60

Convalescence occurred very slowly, without any critical phenomena. The urea gradually increased and the extractive matters diminished.

2. A man aged 66 years, of a muscular frame and good constitution, but of intemperate habits. The disease developed itself with great rapidity. The urine contained:

	On the 4th day.	On the 6th day.
Water	939·30	934·60
Solid constituents	60·70	65·40
Urea	22·84	34·52
Uric acid	1·70	1·62
Alcohol-extract with lactic acid and lactates	20·73	20·20
Water-extract	7·20	8·51
Fixed salts soluble in water	4·02	—
Earthy phosphates	0·72	1·02

3. In a case of typhoid fever of a very putrid character, the

urine was of a red colour and an acid reaction. It contained in 1000 parts:

	1.	2.
Water	983·5	965·3
Solid constituents	16·5	34·7
Urea	1·2	5·3
Uric acid	0·5	1·5
Alcohol-extract, with lactic acid and lactates	6·5	15·8
Water-extract and ammonia-salts	6·2	6·9
Fixed salts soluble in water	1·8	3·6
Earthy phosphates	0·2	0·4
Albumen and mucus	0·5	0·7

The specific gravity in these cases was 1007 and 1011. Analysis 2 was made after the patient had taken phosphoric acid for some days, and the septic tendency had diminished.]

Urine in intermittent fevers.

The urine varies considerably in its physico-chemical relations in this class of fevers. An abundant lateritious sediment at the period of the crisis was formerly regarded as an acknowledged characteristic; recent investigations have, however, shown that this is by no means an invariable occurrence.

Schönlein observes on this point that he feels bound to contradict the old physicians—that the lateritious sediment in the urine discharged at the termination of the paroxysm is a *signum pathognomonicum* of intermittents, and that it may serve for the purpose of distinguishing masked intermittents from similar forms of disease,—because the urinary crisis exhibits itself in various forms, and in many epidemics is either altogether absent, or only forms the exception and not the rule. For instance, when the whole tendency of the disease is directed towards the skin, the crisis is uniformly exhibited through that medium, and an urinary crisis is either altogether absent or only occurs subsequently, during the non-febrile state; so that while a perfectly clear urine is discharged at the termination of the paroxysm, the sediment which has been noticed occurs on the following day.

Becquerel examined the urine in fourteen cases of intermittent fever, ten of which were of the tertian, two of the quartan, and two of the quotidian type. During the intermission the urine resembled the normal secretion, and the resemblance was

closer in proportion to the shortness of the paroxysm and the length of the intermission: the average specific gravity was 1018·9. In many of the cases, the urine during the paroxysm assumed the inflammatory type, that is to say, it was scanty in quantity, highly coloured, and very acid, with or without sediments (either spontaneous or produced by nitric acid), and having a mean specific gravity of 1023·5.

In other cases, in which the febrile paroxysms had been recurring for a length of time, the appearance of the urine changed with the prolongation of the disease; it became paler and less acid, and its specific gravity fell to 1014·7.

The changes produced in the urine by the prolongation of the disease was very striking in the case of a man aged 49 years, who was attacked with a quartan fever during convalescence from acute articular rheumatism. As long as the first disease lasted the urine was inflammatory, but, on the accession of the second, it became paler, less dense, contained a good deal of mucus, and finally became alkaline; the return of the paroxysm did not produce any change in the character of the urine, which remained the same until the recovery of the patient.

In a young chlorotic girl who was attacked with quotidian fever, Becquerel found that the urine was pale, as is the case with chlorotic persons, and was rendered turbid by a large quantity of mucus equally during the intermissions and the paroxysms; but, at the same time, the acidity and density (1021·8—1023·1) were more considerable than is usually the case in chlorosis; and, on cooling, a copious white sediment of uric acid was thrown down.

Becquerel frequently observed turbidity or sediments (either spontaneous or by the addition of an acid) towards the close of intermittent fever, but not earlier. During the paroxysms themselves, the urine was observed to present several modifications. In the majority of cases it seemed to undergo no change during the three stages, that is to say, the urine passed towards the end of the cold stage closely resembled that which was passed during the other stages; sometimes in the cold stage it was deeply coloured, acid, and of rather high specific gravity, and it would retain these characters in the hot stage; sometimes it would be slightly coloured, faintly acid, and of low specific gravity (1013·4) in the cold stage,

and would be darker, more acid, and of higher specific gravity (1021·8) in the hot stage.

Becquerel occasionally observed sediments in the urine at the termination of the paroxysm, but they were by no means of constant occurrence: Andral observed the same. He only noticed them in those cases in which the fever was intense and prolonged, and terminated in a very abundant perspiration, or when it was complicated with functional derangements, or with congestion of certain organs.

The sediment formed in intermittent fevers is always composed of uric acid and urate of ammonia, in most cases combined with red colouring matter (uroerythrin).

A very perfect crisis by the skin and kidneys is said to indicate an erethismic type of fever; an imperfect and slight one, occurring through only one of the secreting organs, a synochal type; and a colliquative crisis, a fever of a torpid character.

In a young man aged 23 years, who was treated in our hospital for quartan fever, the urine, at the end of the paroxysm, always threw down a copious, yellowish-red sediment. During the intermission it was secreted more copiously, was clear, of an amber-yellow colour, contained a few mucous flocculi, and had a slight acid reaction.

[The following table, drawn up by L'Heretier,[1] represents the mean composition of the urine in the different stages of this disease, as deduced from the analyses of the urinary secretion of twelve patients:

	Cold stage.	Hot stage.	Sweating stage.
Specific gravity . .	1017·330	1020·304	1022·820
Water . . .	967·520	964·680	961·845
Solid constituents . .	32·480	35·320	38·155
Urea . . .	9·845	9·015	7·624
Uric acid . .	0·660	0·980	1·029
Salts and organic matter .	21·975	25·325	29·502

In all these cases the physical characters of the secretion were affected by the disease; in six other cases the urine remained apparently normal.]

[1] Traité de Chimie patholog. p. 528.

Scorbutus et Morbus maculosus Werlhofii. (*Land-scurvy.*)

In scurvy the urine is ordinarily of a dark, reddish-brown, and sometimes of an almost black colour. Although it is slightly acid as it passes from the bladder, it very soon becomes alkaline, and develops a strong and disagreeable ammoniacal odour. According to Schönlein, blood is frequently discharged from the urinary organs, and the urine then assumes a dark reddish-brown colour, in consequence of the presence of hæmatoglobulin; in this case, it develops hydrosulphate of ammonia, and soon becomes putrid.

I have examined the urine in three well-marked cases of scurvy occurring in Schönlein's clinical wards; two were men between thirty and forty years of age, and the third, a woman who had been delivered a few weeks previously. In the men, not only were the gums attacked, and the peculiar scorbutic odour observed in the breath, but the lower extremities were covered with numerous ecchymosed spots and petechiæ. The woman had a very cachectic appearance; her face was somewhat swollen; the gums nearly destroyed, livid, and hæmorrhagic; the teeth loose (one having fallen out the preceding night), and the breath almost unbearable. In its physical characters the urine was very similar in these three cases. At first it was scanty (eight to twelve ounces), and of a deep dark-brown colour, as if bile-pigment or decomposed blood were present, which, however, was not the case. It was devoid of the peculiar sweetish odour of typhus-urine, but, after standing a few hours, developed a disagreeable ammoniacal odour.

The addition of ammonia produced a very slight turbidity; and, on the addition of chloride of barium to the urine acidulated with nitric acid, the precipitated sulphate of baryta was much less than in healthy urine. The addition of ammonia (after the removal of the sulphate of baryta) produced a comparatively slight precipitate, showing that there was a deficiency of the phosphates. Infusion of galls, basic and neutral acetate of lead, and acetate of copper, produced considerable turbidity, and the urine was similarly affected (but in a much less degree) by bichloride of mercury. In their chemical characters, these three specimens closely resembled each other, and were found

to approximate to the urine in typhus. The amount of urea was much less than in normal urine, not exceeding 25—30% of the solid residue. The fixed salts were diminished in the urine of the men, forming 14—18% of the solid residue, while in the woman they amounted to 27%, a little above the normal average (25%). The uric acid was slightly above the healthy standard in all the cases, ranging from 1—3% of the solid residue. The men rapidly improved under proper treatment; the urine became more abundant and clearer, and, in the course of six days, was apparently normal. The woman recovered more slowly.

In a girl aged 20 years treated in Schönlein's clinical wards for morbus maculosus Werlhofii, I found the urine, during a period of a fortnight, of a dark brown colour, of a disagreeable ammoniacal odour, and with an alkaline reaction. It deposited a viscid sediment of earthy phosphates, urate of ammonia, and mucus. The addition of nitric acid indicated the presence of a small quantity of bile-pigment. Blood (of which the composition is given in Vol. I, page 316) issued from the mouth, exuding from red patches situated above the uvula. The odour of the breath was putrid. During her recovery, the urine returned to its original state.

[The urine in this disease has likewise been analysed by Heller and Martin.

The two following cases are recorded by Heller:[1]

1. A girl aged 19 years, marked over the whole body, was admitted into the clinical ward of Professor Lippich.

The urine was of an intensely yellowish-brown colour, rather turbid, and deposited flocks of mucus. The odour, at first ordinary, rapidly became ammoniacal; and the same tendency was observed throughout the course of the disease. Reaction faintly acid. Specific gravity 1021. The urine contained in 1000 parts:

Water	949·28
Solid constituents	50·72
Urea	16·21
Uric acid	1·27
Extractive matters with much hydrochlorate of ammonia	23·24
Fixed salts	9·80

[1] Archiv für physiologischen und pathologischen Chemie, vol. 1, p. 12.

The fixed salts consisted almost entirely of earthy phosphates and sulphate of potash, there being a mere trace of chloride of sodium. No albumen was present.

2. In a youth aged 16 years, the urine, during the progress of the disease, was of a brownish-yellow colour and turbid; and when an improvement manifested itself, the secretion became of a lighter tint, and clearer. A sediment of ammoniaco-magnesian phosphate and urate of ammonia was deposited during the disease, but gradually disappeared during convalescence. The urine had a faintly acid reaction, but, notwithstanding, evolved a putrid odour, and very rapidly became alkaline. The specific gravity was at first 1017, and subsequently varied from that number to 1012. Traces of albumen could always be detected till symptoms of convalescence appeared. In its chemical characters it resembled the preceding case. The hydrochlorate of ammonia was much increased, while the chloride of sodium was diminished to a mere trace. The uric acid was much increased, amounting to 2 in 1000 parts. The urine remained abnormal for six days, and then appeared to have resumed its ordinary character.

Heller observes that the augmentation of the ammonia (in the form of hydrochlorate) and of the uric acid, together with the diminution of the chloride of sodium,—characters seemingly associated with this disease,—indicate that the blood must be in a state of dissolution.

In Martin's[1] case, the secretion was very scanty, about one or two ounces being passed at a time, and the daily amount being from twelve to twenty ounces. In its physical characters it resembled the urine described in the preceding cases.

On evaporating the urine, and allowing the solid residue to remain for some hours at a temperature of 212°, there was remarked on the surface of the brown, and (for the most part) saline mass, a copious, reticulated, dendritic efflorescence which, when examined with a lens, was found to consist of long, transparent, four-sided needles, with double-sided sharp extremities. They were proved to be neither hydrochlorates, sulphates, or phosphates, and were presumed to be crystals of hippuric acid. Three analyses were instituted.

[1] Neue med.-chir. Zeit. 1845.

	1.	2.	3.
Specific gravity	1013·40	1021·26	1010·31
Water	984·42	973·74	985·730
Solid constituents	15·58	26·26	14·270
Urea	6·43	6·07	5·430
Green colouring matter (thrown down by hydrochloric acid in place of uric acid)	0·09	0·10	0·006
Extractive matters with ammonia-salts, &c.	2·34	2·25	0·650
Fixed salts soluble in water	6·30	17·00	7·794
„ insoluble in water	0·42	0·84	0·390

Analysis 1 was made on Oct. 22d, before the administration of any remedies. The urine was faintly acid. The soluble salts consisted for the most part of chloride of sodium. Analysis 2 was made on the 3d of November with the mixed urine of the preceding twenty-four hours. It had a strong ammoniacal odour, but was perfectly neutral. The patient had taken sulphuric acid, iron, and other tonics, in the interval, without any obvious improvement, and traces of iron were found with the earthy phosphates. Analysis 3 was made with the morning urine passed on the 25th of November. The same treatment had been pursued with very decided benefit. The urine was clear, slightly yellow, and devoid of the unpleasant odour it previously evolved. Its reaction was faintly acid, and it contained traces of iron.

The green colouring matter is probably a compound of uric acid and biliphæin. A compound of this nature has been observed and described by Heller.[1]]

Chlorosis.

The urine of chlorotic persons is usually pale, of low specific gravity, and of a mildly acid reaction : in these respects it resembles the urine of persons who have lost a considerable quantity of blood, or the form of urine termed nervous, which we sometimes observe in hysterical attacks.

Becquerel applies the term *anæmic* to this form of urine, and, as in the majority of cases in which it occurs, there is either an absolute deficiency of blood or a scarcity of the truly vital portion—the blood-corpuscles, no objection can be raised to such a designation. The urine in chlorosis has, however, other dis-

[1] Archiv für phys. und pathol. Chemie, vol. 1, p. 99.

tinctive properties, as has been clearly shown by the researches of Becquerel; for it is very poor in urea, and in that respect resembles the urine in typhus, while it differs from the latter in containing only a small quantity of uric acid, and a large amount of fixed salts.

I may perhaps be allowed to refer once more to the intimate connexion subsisting between the action of the metamorphosis of the blood-corpuscles (or of their development and vitality) on the one hand, and on the production of urea on the other.

The proportion of the urea to the solid constituents of the urine in inflammatory diseases, in those forms of typhus which assume a torpid character, and lastly in chlorosis, affords us sufficient illustration of this connexion.

In the form of typhus to which we have alluded, as well as in chlorosis and anæmia, the urea is diminished; but, as we have already remarked, in that case the uric acid, which is a product peculiar to febrile action, is increased, and the salts (partly in consequence of the diet) are diminished; while in chlorosis, in which a nutritious nitrogenous diet is allowed, the diminution of the urea plainly indicates that the seat of the disease must be sought for in the production of the blood-corpuscles.

I shall now give Becquerel's account of the chemico-physical relations of the urine in chlorosis.

The quantity of urine emitted in twenty-four hours amounts to about 34 ounces. It is pale and of a greenish tint, and only becomes dark when the urine is very concentrated: the acid reaction is weak; uric-acid sediments are seldom formed; when they do occur, they are of a white or gray colour. If, as is not unfrequently the case, leucorrhœa is associated with chlorosis, the urine is more or less turbid in consequence of the mixture of the morbid product with it; in these cases a little albumen is generally observed.

The quantitative analyses which Becquerel made of the urine of chlorotic persons gave the following results:

	Anal. 1.	Anal. 2.	Anal. 3.
Quantity of urine in 24 hours .	41·3 ounces	50·8 ounces	27·5 ounces
Specific gravity . .	1011·3	1012·6	1016·8

1000 parts contained:

Water	981·28	979·21	972·28
Solid residue	18·72	20·79	27·72
Urea	6·03	7·38	6·83
Uric acid	0·08	0·26	0·23
Fixed salts	4·80	8·05	8·45
Extractive matters	7·79	5·14	11·16

If we calculate the amount of urea, uric acid, and fixed salts in these analyses in relation to 100 parts of solid residue, and compare the results with the physiological average which Becquerel has given, the proportions to which I have already alluded will plainly appear, that is to say, there is an absolute and a relative diminution of urea and of uric acid, and an increase of the fixed salts; 100 parts of solid residue contain:

	Anal. 1.	Anal. 2.	Anal. 3.	Normal Urine.
Urea	32·0	33·0	24·0	42·0
Uric acid	0·4	1·2	0·8	1·4
Fixed salts	26·0	38·0	30·0	24·0

The urine may exhibit some differences in its chemico-physiological properties if other diseases are associated with chlorosis, or if the latter is not very fully developed. The persons from whom the urine in analyses 1 and 2 was taken were slightly feverish. In analysis 3, the chlorosis was combined with pulmonary emphysema. In analysis 4, there was some affection of the nervous system.

With the exception of a considerable diminution in the quantity of urine discharged in twenty-four hours in analyses 1 and 3, and the increase of uric acid in analysis 2, there are no particular deviations in the relative proportions of the solid constituents from the statement that we have previously made; for the urea is both absolutely and relatively diminished, and the salts occur in a higher proportion than in normal urine.

	1.	2.	3.	4.
Quantity of urine passed in 24 hours, in ounces	23·3 oz.	24·5 oz.	17·8 oz.	38·5 oz.
Specific gravity	1014·2	1017·6	1016·8	1016·8

1000 parts contained:

Water	976·43	970·89	972·28	972·28
Solid constituents	23·57	29·11	27·72	27·72
Urea	8·37	7·81	8·64	6·95
Uric acid	0·20	0·81	—	0·22
Fixed salts	4·74	0·09	8·36	8·89
Extractive matters	10·34	11·47	10·24	12·10

Becquerel has made some interesting remarks on the influence of ferruginous preparations on the urine in chlorosis.

In the majority of cases the iron is partially carried off by the urine; sometimes, without any apparent reason, it is absent from urine in which it is found on the preceding and succeeding days. The quantity of iron thus carried off in the urine of the same individual is subject to great variations; sometimes it can only be detected after the incineration of a portion of evaporated urine, while, on other occasions, the simple addition of a test is sufficient to indicate its presence. The iron begins to pass off by the urine from the commencement of the administration of the medicine, and it occurs in all the urine that is emitted; so that there is no necessity for the system to be saturated with it before any portion can pass off by the kidneys; as the assimilation of the iron is a very slow process, large doses merely derange the digestive organs without being of more service than smaller doses.

[Herberger[1] analysed the urine of the chlorotic girl referred to in Vol. I, p. 313, and his analyses indicate the simultaneous diminution of the blood-corpuscles and urea. The urine was analysed on three occasions before the use of iron, and twice afterwards.

Urine before the use of iron.

	1.	2.	3.
Specific gravity	1010	1009	1012
Quantity in 24 hours	32 oz.	42 oz.	35 oz.
Water	975·43	978·21	971·98
Solid constituents	24·57	21·79	28·02
Urea	7·04	7·00	7·12
Uric acid	0·13	0·21	0·19
Extractive matters	10·48	9·00	13·99
Fixed salts	6·80	5·50	6·62

Urine after the use of iron.

	1.	2.
Water	940·16	938·70
Solid constituents	59·84	61·30
Urea	26·84	27·36
Uric acid	0·94	0·96
Extractive matters	18·62	16·28
Fixed salts	13·32	15·71

[1] Buchner's Repertorium, vol. 29.

Traces of iron were detected both in the sweat and urine during the period of treatment.]

Donné states that normal urine always contains a certain quantity of iron which disappears during chlorosis, and only reappears after the use of ferruginous preparations. This statement is contradicted by Becquerel, who has never been able to discover iron in the incinerated residue of normal urine, although ferrocyanide of potassium would evolve a blueish shade,—an effect which this test sometimes has on chlorotic urine.

[L'Heretier[1] gives the mean of eight analyses of the urine in uncomplicated chlorosis:

		In 24 hours.
Quantity of urine	1000	38 oz.
Specific gravity	1011·9	—
Water	983·1	18372 grains
Solid constituents	16·9	316
Urea	6·6	123
Uric acid	0·2	5
Fixed salts	4·1	77
Organic matter	6·0	111

I am indebted to the kindness of Dr. Golding Bird for the following cases:

1. A girl aged 18 years, of anæmic appearance, and who had suffered from anasarca for six months, passed 30 ounces of acid urine of specific gravity 1024, in twenty-four hours.

The water amounted to	12690 grains.
The solids	750
Urea	162
Uric acid	9

She then commenced taking *ferri sulph.* gr. iij, *ter die.* In the course of a week the urine was again examined; it amounted to 20 ounces, had a specific gravity of 1029, and deposited urate of ammonia.

The water amounted to	8392 grains.
The solids	608
Urea	137
Uric acid	20

[1] Traité de Chim. patholog. p. 551.

The anæmia was now disappearing. At the end of the second week the amount of urine was 30 ounces, and the specific gravity 1023.

The water amounted to . .	12690 grains.
The solids	720
Urea	242
Uric acid	5

2. The urine of a girl aged 15 years, of chlorotic appearance but menstruating regularly, amounted to 25 ounces, and had a specific gravity of 1020.

The water amounted to . . .	10637 grains
The solids	519
Urea	231·25
Uric acid	25·00

The amount of uric acid in this case is very remarkable.]

Hæmorrhages.

The properties of the urine in hæmorrhages are entirely dependent, during the period of the discharge and for some short time afterwards, upon the degree in which the vascular system participates in the general disturbance. In many cases, as for instance, in cerebral and pulmonary hæmorrhages, we find that the quantity of urine is diminished, its colour becomes deepened, its acidity and its specific gravity increased,—that is to say, it entirely resembles inflammatory urine. When there is hæmorrhage from the kidneys, uterus, or any portion of the generative system, the urine will naturally contain blood, either in a state of solution or undissolved. If the hæmorrhage is succeeded by a state of anæmia and great prostration of strength, the urine then becomes pale, of slight acidity, and of low specific gravity, as in chlorosis.

Becquerel made three examinations of the urine in cerebral hæmorrhage, and in two of these cases he found it analogous in its physical relations to the urine of inflammation: in the third case, in which the patient had imperfect hemiplegia of the right side, but in other respects seemed well, the urine could hardly be considered abnormal.

In one of the first two cases, the urine was taken from a man aged 43 years, who was affected with perfect paralysis of

the left side, and died on the fifteenth day from the seizure. It exhibited in a high degree, both in its physical properties and in its chemical constitution, the characters of inflammatory urine. The quantity was diminished; the specific gravity, the urea, and uric acid exceeded the physiological average.

Quantity of urine in 24 hours, in ounces	25·7
Specific gravity	1023·1
Water	960·40
Solid residue	39·60
Urea	17·10
Uric acid	0·65
Fixed salts	10·00
Extractive matter	11·80

In 100 parts of solid constituents there are 43·0 of urea, and 1·6 of uric acid.

The urine of a man aged 31 years, who was treated in Schönlein's clinical wards for a severe attack of pulmonary hæmorrhage, was of a dark red colour, very acid, and exhibited the other symptoms of the inflammatory type, from the period of admission to the eleventh day. On two occasions I found its specific gravity to be 1023 and 1022. On the eleventh morning the urine was rather turbid, and on the twelfth it became jumentous from the urate of ammonia which was suspended in it; it still had a strong acid reaction, but did not form any sediment; on the next day, the sediment was very considerable. The pulse was quick and feverish till the urine began to deposit sediments; subsequently, the vascular excitement almost entirely disappeared, and the urine became clear and pale, and contained only a few mucous flocculi.

In a girl aged 20 years, with severe hæmatemesis, who had brought up nearly a quart of coagulated blood, the urine which was passed almost immediately after the attack scarcely differed from the normal secretion; but, on the following day, it was pale, and scarcely acid, and it continued in this state for several days.

In hæmaturia the urine contains blood, either in a coagulated state or devoid of fibrin; in the latter case, the blood-corpuscles may be either perfectly dissolved or not; and when they are found floating in the urine, they form, after a short time, a red sediment. More minute observations on this subject have been given in page 187.

Rayer has published a very interesting communication on an endemic hæmaturia that occurred in the Isle of France. Children of very tender age discharged blood with the urine; he relates for instance, the case of a boy, who from his seventh year lost nearly an ounce of blood daily: uric-acid gravel was combined with the hæmaturia.

A man aged 21 years, from the Isle of France, who was under Rayer's care, had had hæmaturia from his youth. The urine which he passed in Rayer's presence formed, in the course of seven hours, a cream-like layer on the surface; two distinct strata were afterwards formed, the upper being of a yellowish-white colour, and the lower red: the latter contained two clots of coagulated matter, one was the ordinary blood-clot, the other was white and loose. The upper milky stratum contained much albumen and fat (chylous urine), the lower one contained blood. No casein was present. It is worthy of remark that the hæmaturia never came on till about noon, the urine passed in the earlier hours being always clear.

Rayer and Orfila also observed a similar case of bloody and milky urine in a Brazilian. The disease commenced with a discharge of milky urine, the hæmaturia coming on a year afterwards.

Catarrhs.

In simple catarrh the state of the urine corresponds with the degree of vascular reaction.

If the catarrh terminates without any perceptible fever, the urine scarcely deviates at all from the normal state: if the fever is accompanied by much excitement, the urine, according to Schönlein, becomes rather red, and forms a mucous sediment. At the commencement of convalescence from a feverish catarrh the urinary crisis shows itself by a mucous sediment.

In influenza the urine assumes a reddish tint, and assumes more or less of the inflammatory type in proportion to the synochal character of the fever. Schönlein states that the nature of the urinary crisis at the approach of convalescence is dependent on the character of the fever: in erethismic fever the sediment is mucous, in synochal fever it is earthy, and in gastric fever it is of a yellowish-gray colour.

In measles, which are considered by Schönlein as the most highly-developed form of catarrhal disease occurring in the northern hemisphere, the urine changes with the varying stages of the disorder. In most cases it more or less resembles the inflammatory type, it is red (as in inflammatory measles), acid, and sometimes jumentous (as in gastric measles), or deposits a mucous sediment during the course of the morning (as in catarrhal measles). Becquerel states, as the result of his observations, that the urine is generally inflammatory at the commencement of the febrile period. It becomes very dark and of high specific gravity, and frequently deposits a sediment of uric acid: a small quantity of albumen was found in a few of the cases. During the eruptive period the character of the urine changes; if the eruption is slight, and there is not much fever, it resumes the normal type; if the contrary is the case, the urine retains the inflammatory appearance. Becquerel did not meet with any case in which the urine was turbid or sedimentary towards the close of the eruptive stage.

During the period of desquamation and of convalescence, the urine either returns at once to the normal state, or continues turbid and sedimentary for some time, or becomes pale, clear, and anæmic.

In three cases anasarca came on during convalescence, but the urine did not contain albumen.

During the catarrhal affection of the mucous membrane of the stomach, or the *status gastricus* (as it has been called), which when more fully established, becomes gastric fever, the urine is generally more or less turbid, and earthy sediments appear as symptoms of a crisis.

Becquerel found that the urine in "l'embarras gastrique" was often of a deep colour, and sedimentary, as in the phlogoses: sometimes, however, it hardly differed from the normal secretion. Out of twelve cases, the urine in two scarcely differed at all from the normal type, in the other ten it approximated more or less in its characters to the urine of inflammation: the deepness of the colour appeared to be always in relation to the intensity of the disorder, and to the presence of some degree of

fever. In the twelve cases, with two exceptions, the urine was constantly acid. In one of the exceptions the urine was alkaline, and contained numerous crystals of ammoniaco-magnesian phosphate. In six cases sediments of uric acid were formed either spontaneously, or on the addition of an acid: in two in which the symptoms were very intense, a little albumen was present, but in each case it lasted only one day. The mean specific gravity of the urine was 1021·4; the highest, and in this case a sediment was deposited, was 1025·2.

In gastric fever the urine is frequently turbid and jumentous: it usually contains urate of ammonia in suspension, and has an acid reaction. An earthy flocculent sediment occurs as a urinary crisis at the commencement of convalescence, the supernatant fluid being clear. (Schönlein.)

In mucous fever the urine is red and fiery, if the fever (which at the commencement assumes the intermittent type, and which only at a later period becomes continuous,) takes on a synochal character.

It is not unfrequently limpid and clear, as in hysterical cases, and forms, especially if the affection has extended to the genito-urinary mucous membrane, a mucous sediment. In those cases in which the urine is limpid, it assumes the normal colour during the progress to convalescence, and sediments are deposited which gradually become thicker, and pass from a mucous to an earthy-purulent character. (Schönlein).

The urine in bilious fever is usually impregnated with bile-pigment; it is of a more or less brownish colour, and when a thin layer is seen it appears of a citron-yellow tint: it differs, however, with the degree of vascular excitement; if the fever has a synochal character the urine is dark and of a fiery-red colour, if the fever is erethismic, which is frequently the case, it is of a dark yellow or yellowish-brown colour, and in torpid fever it is more or less brown, and not unfrequently mixed with blood. The presence of bile-pigment may always be recognized by the change of colour which succeeds the addition of nitric acid.

Cholera.

In sporadic cholera, as well as in the Asiatic form of the disease, the urinary secretion is very scanty, and sometimes altogether suppressed. Any urine that is discharged is usually of a dark colour, and has a feeble acid reaction, but its specific gravity is below the healthy average.

In a case which I observed in our hospital, where the symptoms were exhibited with great severity in a woman 36 years of age, there were frequent evacuations by stool, but only about one ounce and a half of dark acid urine, with a specific gravity of 1011·0, in the course of twenty-four hours. I only determined the amount of solid constituents collectively, and of the urea.

In 1000 parts I found:

	Analysis 118.
Water	975·90
Solid constituents	24·10
Urea	7·10

The urea in this case amounts to rather more than 29% of the solid residue, which is considerably below the normal proportion. At the approach of convalescence the urine was discharged more copiously, but it continued to be deeply coloured: it was only after some days that it became pale and anæmic. I never observed any sediment.

[The urine of a man aged 30 years, attacked with sporadic cholera, was analysed by Heller.[1] There was excessive diarrhœa and vomiting, and the patient died on the fourth day.

During the first forty-eight hours of his illness only one ounce of urine was discharged; it had a deep golden-yellow colour, and deposited earthy phosphates although strongly acid. Its specific gravity was 1018. It contained in 1000 parts:

Water and free carbonic acid	955·67
Solid constituents	44·33
Urea	10·50
Uric acid	0·10
Extractive matter, with a large quantity of a peculiar substance apparently originating from the bile	27·32
Fixed salts	6·41

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[1] Archiv für phys. und pathol. Chemie, vol. 1, p. 15.

We are unfortunately not possessed of any trustworthy information respecting the urine in Asiatic cholera. R. Herrmann[1] has communicated the following remarks.

As no opportunity occurred for obtaining urine passed during the more urgent stages of the disease, that which was first discharged by a patient who was just getting over a severe attack was analysed: it was yellowish, turbid, deposited no sediment, had a neutral reaction, and by the application of appropriate tests, the presence of phosphates, hydrochlorates, and ammonia-compounds was indicated; on the addition of nitric acid, crystals of nitrate of urea were obtained; but only small quantities of all those substances were present. Its specific gravity was very low, being only 1006.

Wittstock[2] has likewise instituted some researches on the urine which was passed immediately after an attack of cholera. It had a specific gravity of 1008·5, was neutral, of a pale yellow colour, but not perfectly transparent in consequence of microscopic crystals (consisting, in all probability, of ammoniaco-magnesian phosphate,) held in suspension. The sides of the glass were also covered with minute glittering crystals, which were supposed by Wittstock to consist of uric acid, but which, in all probability, were composed of ammoniaco-magnesian phosphate also.[3]

An interesting investigation regarding the urine in cholera has also been made by Vogel. The urine was passed after the most violent symptoms had abated: it was of a deep brownish-yellow colour, was rather turbid, deposited no sediment, had a specific gravity of 1008·0, and indicated a strong acid reaction. The salts of lime and magnesia were entirely wanting, and the quantity of chloride of sodium was very minute, while on the other hand the sulphates were found in a larger proportion than in normal urine.

The existence of bile-pigment and of albumen was proved by

[1] Poggendorff's Annalen, vol. 22, p. 176. [2] Cholera Archiv, vol. 1, p. 428

[3] It is by no means probable that urine, with so low a specific gravity, and especially when it is alkaline or neutral, should throw down a precipitate of uric acid; a sediment of urate of ammonia would be much more probable. The neutral state of the urine would favour the separation of crystals of ammoniaco-magnesian phosphate, as suggested in the text.

the addition of nitric acid to the urine. Urea, uric acid, mucus, and a good deal of phosphoric and lactic acid were present. Subsequently the albumen and bile-pigment disappeared, and the earthy phosphates returned.

In vesical catarrh the urine is generally very pale, and always contains a greater or less amount of mucus. The feeble acid reaction which it possesses at the period of its emission is frequently lost in a very short time, and it becomes neutral or alkaline, and a quantity of the earthy phosphates, (especially of crystals of ammoniaco-magnesian phosphate,[1]) becomes mixed with the mucus. The quantity of mucus which is separated is sometimes very bulky.

Schönlein remarks that we may possibly be able to determine the seat and the extent of the blennorrhœa from the quality and the amount of mucus. Mucus secreted from the mucous membrane of the bladder forms an uniform mass, and is tenacious and thready, while that secreted by the mucous membrane of the ureters and of the pelvis of the kidney is, on the contrary, flocculent: if the tenacious and the flocculent forms of mucus are both found at one and the same time, we are justified in assuming that the bladder, ureters, and pelvis are simultaneously affected. Willis,[2] in speaking of cystorrhœa, states that in acute vesical catarrh accompanied by inflammatory fever, the urine is scanty and highly coloured, and precipitates a much greater quantity of tenacious mucus than usual; also that in the earlier stages of the disease it is sometimes ammoniacal, but more frequently when the disease has continued for a long time. In chronic vesical catarrh the urine is flocculent when it is passed; the flocculi increase with the advances of the disease, and collecting at the bottom, form a tenacious mass which may be drawn out into threads; this mass sometimes assumes the consistence of bird-lime, and exhibits spots of blood.

As the disease advances still further, we often find a fourth or even a third part of the urine to consist of mucus, so that six to eight or even ten ounces are daily thrown off. Willis

[1] [It is worthy of observation that beautiful crystals of ammoniaco-magnesian phosphate may be occasionally found in urine with a decidedly acid reaction.]

[2] Urinary Diseases and their Treatment, p. 399.

inquires whether this secretion is always composed of actual mucus, or whether pus in a modified form is not always present.

In the urine of a man who was being treated for catarrhus vesicæ in our hospital, I found a very bulky sediment composed of mucus and earthy phosphates: the quantity of ammoniaco-magnesian phosphate was also very considerable.

The urine upon becoming clear above the sediment, was of a faint yellow colour, and contained much carbonate of ammonia; it constantly had an alkaline reaction. The sediment for a period of eight days assumed a faint grayish-blue colour; when washed (for the purpose of separating the urine from it as completely as possible,) and dried, it was treated with anhydrous alcohol, which took up the blue colouring matter, and on evaporation left it as a beautiful blue substance insoluble in water, but dissolving in ether with a reddish tint; I can only compare it to Braconnot's cyanourin.

Rheumatism.

We have already seen that the blood in rheumatism perfectly corresponds with the blood in the true inflammations; hence we are led to infer that the urine will also present the inflammatory type—an inference confirmed by experiment.

The urine in acute rheumatism, (when the reaction is accompanied by synochal fever,) exhibits in a high degree those characters of inflammatory urine which I have already so often described. The colour is sometimes deep purple-red, like claret, its acid reaction is very strongly developed, and very bulky, fawn-coloured or lateritious sediments consisting for the most part of urate of ammonia, but occasionally of crystallized uric acid, are deposited. The extent to which these properties of the urine are exhibited depends upon the violence, and the more or less synochal character of the fever.

Vauquelin and Henry found free phosphoric acid, and the latter also free acetic acid, in the urine.

In chronic rheumatism without fever, the characters of inflammatory urine may be altogether absent, and instead of the earthy sediments we shall have merely a cloudiness and turbidity, as I have observed in my own case. The urine which I have passed during the night has frequently remained perfectly

clear, while that discharged in the course of the day often formed only slight deposits. As the urine in rheumatism often throws down sediments even at the height of the disease, the deposits which are formed can only be regarded as significant of a true crisis when the supernatant urine is perfectly clear. Eisenmann[1] remarks that the properties of the urine may undergo a change if the disease continues for a long time; for instance, if it should take a hypodynamic character, the urine, instead of being acid, will assume an alkaline reaction, and will give off a fetid ammoniacal odour.

When the disease takes on the hypodynamic type, without having previously exhibited a hyperdynamic character, the urine instead of being red, is then, according to Stork's observations, pale, frequently thick, turbid, and fetid.

Becquerel has made quantitative analyses of the urine in several cases of rheumatism. He found the relative proportions of the solid constituents the same as in inflammation—a fact that had been previously observed by Henry[2] who found a large amount of urea in his own urine during rheumatic fever.

The urine of a man aged 30 years (Anal. 1), who had been bled for acute rheumatism, was very deeply coloured, and on the addition of a little nitric acid threw down a copious sediment. It also threw down a spontaneous sediment of a reddish colour after standing for two hours. The specific gravity was 1017·2. The urine of the same man was analysed another day, (Anal. 2). It was of a very dark colour, almost like blood, and had a specific gravity of 1018·0. The urine in the third analysis was taken from a man aged 38 years, whose pulse was 104 in the minute. It was of yellowish-red colour, and threw down a sediment of uric acid on the addition of a few drops of nitric acid.

	1.	2.	3.
Water	971·80	970·20	981·10
Solid constituents	28·20	29·80	18·90
Urea	12·20	9·00	8·00
Uric acid	1·70	1·04	0·50
Fixed salts		5·59	2·34
Extractive matter		14·70	8·00

[1] Die Krankheitsfamilie Rheuma, p. 51.

[2] Journ. de Pharm. 15, p. 228.

If we calculate the amount of urea and of uric acid in proportion to 100 parts of solid residue, we obtain 43% urea and 6% uric acid in the first, but only 31% urea, and 3·5% uric acid in the second analysis; so that in the first analysis the physiological average is exceeded, while in the second it is not reached, at least as far as the urea is concerned.

In the third analysis the numbers approximate closely to the physiological average, viz. 42% urea and 2·6% uric acid.

In eighteen cases of rheumatism, in which the renal secretion was examined by Becquerel, it always assumed to a greater or less degree the characters of inflammatory urine during the continuance of the fever: the very deep colour was general, as also the acid reaction, except in one case, in which for a single day an alkaline reaction was observed. The mean specific gravity was 1022·6: in those cases which threw down a spontaneous sediment it was 1025·2. In twelve out of the eighteen cases, a spontaneous sediment was thrown down during the febrile period: these sediments usually alternated with dark but clear urine, or with urine that was precipitable by nitric acid.

Albumen was detected in seven of the eighteen cases. During the period of convalescence the urine was anæmic, or returned to its normal state.

[The following analysis of the urine of a man aged 22 years, suffering from acute rheumatism, was made by Dr. Baumert.[1] The urine submitted to analysis was passed on the fourteenth day of the disease. It was of a deep yellowish brown colour but perfectly clear. In the course of twenty-four hours it deposited a copious sediment of urate of ammonia, but did not become alkaline.

It presented the normal degree of acidity, and its specific gravity was 1028·3. It contained in 1000 parts:

Water	928·68
Solid constituents	71·32
Urea	18·65
Uric acid	0·86
Extractive matter with a large quantity of hydrochlorate of ammonia	37·61
Fixed salts	14·20

[1] Archiv für phys. und patholog. Chemie, vol. 1, p. 45.

The fixed salts contained no trace of chloride of sodium, the normal amount of earthy phosphates, a slight excess of alkaline phosphates, and an augmentation of the sulphates.

Hippuric acid was sought for without success.

Oxalate of lime is of frequent occurrence in cases of acute rheumatism.]

In chronic rheumatism, if the pains are not very acute, and the night's rest is not disturbed, the urine retains its normal properties. Out of thirty-seven cases observed by Becquerel, the urine remained unaffected in twenty, while in seventeen it assumed the inflammatory type, and in nine of these threw down a spontaneous sediment.

Gout.

I have made four analyses of the urine in two cases of gout, with the view of determining the effect of benzoic acid on that secretion:

	Before administration. Anal. 119.	After ditto. Anal. 120.	Before administration. Anal. 121.	After ditto. Anal. 122.
Water	976·73	978·84	965·25	962·43
Solid constituents	23·27	21·16	34·75	37·57
Urea	7·02	6·10	9·23	10·00
Uric acid	0·50	0·48	0·58	0·60
Earthy phosphates	0·35	—	0·28	—
Sulphate of potash	2·67	—	2·08	—
Phosphate of soda	1·60	—	4·53	—
Hippuric acid	—	0·65	—	0·69

If we determine the per centage of the urea and uric acid in relation to the solid residue, we find in the first case, that before the use of benzoic acid the urea amounted to 30·16% and the uric acid to 2·14%, and afterwards they amounted to 28·21% and 2·22% respectively. In the second case the urea and uric acid amounted to 26·56% and 1·66% before the use of the acid, and 26·61% and 1·59% afterwards.

These analyses are insufficient to show that benzoic acid exerts any influence on the amount of urea or uric acid. The clinical experiments of Froriep and others indicate, however, that it is a valuable remedy in various forms of arthritis.

Froriep[1] has published a notice of twenty cases of gout and

[1] Simon's Beiträge, p. 294.

chronic rheumatism in which he administered benzoic acid. During the first twenty-four hours the symptoms are always aggravated, but they usually subside on the second day.

The Exanthemata.

In all the acute exanthemata the urine very frequently presents, as Schönlein remarks, a peculiar character, which is due, in many cases, to an admixture of bile-pigment: it has a dark-brown colour, and resembles badly-fermented beer in appearance. At the commencement of the crisis the urine becomes clearer, and forms a pulverulent sediment consisting of uric acid (and perhaps urate of ammonia).

In the fever which accompanies erysipelas, and is usually of an erethismic or synochal character, the urine is frequently loaded with bile-pigment, and is of a reddish-brown or red colour. At the urinary crisis, fawn-coloured precipitates are deposited, and the urine becomes clear. (Schönlein.)

Becquerel has examined the urine in several cases of erysipelas.

When the erysipelas is accompanied by fever, as is most commonly the case, the urine assumes the inflammatory type. Becquerel made two quantitative analyses of the urine of a man aged 39 years, who had erysipelas of the face, and a good deal of fever (pulse 112).

The urine of the first analysis was of a deep yellowish-red colour, and clear; its specific gravity was 1021·0.

The urine of the second analysis was so deeply coloured as to appear almost black; it threw down a reddish sediment of uric acid, and had a specific gravity of 1023·1.

The first analysis was made on the fourth, and the second on the sixth day from the commencement of the disease.

These analyses gave:

	Anal. 1.	Anal. 2.
Quantity of urine passed in 24 hours, in ounces	27·0	30·8
Water	965·5	961·9
Solid constituents	34·5	38·1
Urea	12·5	12·7
Uric acid	1·2	1·3
Fixed salts	—	8·2
Extractive matter	—	15·9

In a woman aged 45 years, with erysipelas of the face,

whose pulse was 104 and full, the urine was very scanty, of a dark-brown colour, strongly acid, threw down a yellow sediment spontaneously, and had a specific gravity of 1023·1.

It contained:

Water	961·7
Solid constituents	38·3
Urea	11·7
Uric acid	1·3
Fixed salts	9·2
Extractive matters	15·7

In five cases in which the morning urine was daily examined with care, the characters of inflammation were present in a very high degree: the specific gravity varied from 1021 to 1025. In four of these cases the urine threw down a reddish sediment, and in two a little albumen was occasionally present.

In scarlatina, the urine at the commencement, while there is considerable fever, is of a deep dark-red colour, and possesses all the properties of inflammatory urine.

In children the urine is always less coloured than in adults, and its colour in this disease is proportionally less dark.

It almost always has an acid reaction, and only exhibits a tendency to become rapidly ammoniacal, when the disease is associated with a nervous or septic condition of the system. Any sediments that may be formed consist, for the most part, of urate of ammonia and uric acid mixed with a greater or less quantity of mucus: blood-corpuscles are occasionally noticed. When the urine is ammoniacal, viscid whitish sediments of the earthy phosphates are deposited, and if there is much gastric disturbance the urine becomes jumentous. Albumen is commonly but not always found in the urine during the period of desquamation. Dropsy may even supervene without the urine becoming albuminous: it is sometimes preceded by the occurrence of hæmaturia.

Becquerel found that the urine during the febrile period was generally very high coloured, and, if severe angina was present, was very acid, and was either turbid, or became so on the addition of an acid: it frequently also formed a gray or lateritious sediment, and the presence of a small quantity of albumen

was by no means rare. Becquerel only observed blood in the urine in the single case of a child five and half years old, who was attacked with anasarca. In a girl whose nervous system was very much deranged during the period of the febrile invasion, the urine was very deeply coloured, turbid, and deposited on the sides of the vessel a copious precipitate of a bright red colour. The sediment disappeared when the eruption was fully established. Blood was frequently observed in the urine when there were symptoms of impending dissolution during the nervous form of scarlatina; the quantity was sometimes very considerable, and the corpuscles could be readily detected by the microscope. The appearance of blood in this state must be distinguished from that in which it arises from a renal affection (Bright's disease) in which Becquerel has frequently observed it, and where, in the fatal cases, the existence of Bright's disease was proved. The amount of albumen in the urine is, in these cases, constant and larger than is frequently found in inflammatory diseases, without the occurrence of any simultaneous dropsical symptoms.[1] During the period of desquamation symptoms of dropsy frequently supervene, and the urine often contains albumen, in larger amount and more continuously than is usually the case in inflammations.

The observations regarding the presence of albumen during the period of desquamation after scarlatina are so contradictory that it has become a matter of very great interest to settle these conflicting statements by further researches. We have dropsical symptoms with albuminuria, dropsical symptoms without albuminuria, and albuminuria without dropsical symptoms. Solon found albumen in the urine in twenty-two out of twenty-three cases of scarlatina. On the other hand, Philipp[2] observed, in Berlin where scarlatina was recently very prevalent, and anasarca could not be warded off, at least sixty cases in which the urine was tested both with heat and nitric acid, and no trace of albumen could be detected.

In two cases of scarlatina that were being treated in Romberg's

[1] When the urine contains no blood-corpuscles visible by the microscope, dissolved hæmatoglobulin may be present, which can be estimated in the manner described in p. 187.

[2] Casper's Wochenschrift, 1840; No. 35.

clinical ward for children, and in which there were no dropsical symptoms, I could find no albumen. In the case of a man aged 20 years, which occurred in Schönlein's clinical wards, the urine was very albuminous during the period of desquamation, and continued so for four days without the occurrence of dropsy; in another man, in whose urine I found no albumen, there were also no dropsical symptoms.

In a boy aged 5 years, who was suffering from septic scarlatina just then at its acme, (putrid odour from the mouth and nose, and disturbance of the cerebral faculties,) the urine was of a dark-yellow colour, had an alkaline reaction, a very disagreeable ammoniacal odour, and threw down a dirty white sediment of earthy phosphates, urate of ammonia, and urate of soda;—the latter occurring in the form of opaque globules. The specific gravity was 1022, and about 16 ounces were discharged in the course of twenty-four hours. There were contained in 1000 parts:

	Analysis 123.
Water	943·60
Solid constituents	56·40
Urea	19·35
Uric acid	1·69

The uric acid was combined with ammonia and soda. I examined the urine of the same boy afterwards, and found that it possessed precisely similar characters: it was of a straw-colour, had an alkaline reaction, and an ammoniacal odour; the sediment was more copious than on the former occasion, and there were considerably more of the large opaque globules, which I consider to be urate of soda. During the period of desquamation I found a greater number of mucus-corpuscles in the sediment than is usual, but nitric acid gave no indication of albumen. The urine above the sediment remained turbid in consequence of holding in suspension a very large quantity of epithelium, which was swimming about, partly in single scales, and partly in fragments of 8-12 scales connected with each other, and all of which were acted on by some chemical agent, probably by the carbonate of ammonia in the urine.

This sediment should always be sought for with as much care as albumen. It is an indication of the desquamation of

the mucous membrane, and is frequently a precursor of the desquamation of the cuticle. The tubes described as occurring in Bright's disease are occasionally found in this form of sediment.

In variola and varicella the urine changes with the various stages of the disease, and with the nature of the fever which is present.

Urine of a synochal character is, however, often met with, especially during the first stage of the disease, when the fever has a synochal type.

Becquerel examined the urine of eleven persons with variola, and of ten with varicella. In a case of varicella in which the early symptoms (les prodromes) were extremely severe, the urine was passed in very small quantity, of a deep red colour, and a specific gravity of 1022·7.

In a case of varicella in which the early symptoms were scarcely perceptible, the urine remained normal. Schönlein states that in the first stage of this disease the urine is often as limpid as in hysteria. During the eruptive stage, the state of the urine depends upon the intensity of the fever which accompanies the appearance of the exanthema.

In five out of the eleven cases of variola observed by Becquerel the symptoms accompanying the eruption were very severe; the urinary secretion was diminished, and amounted on an average to only 23·5 ounces in twenty-four hours. The specific gravity had not, however, increased so much as might have been supposed, being only 1020·6. It frequently threw down uric-acid precipitates, either spontaneously, or on the addition of nitric acid, and in one case a little albumen was observed.

M. Solon found the urine coagulable in five out of eleven cases of variola. When the inflammatory symptoms, during the eruption, are slight, the urine hardly differs from the normal state. During the suppurative stage of variola, Becquerel observed that the urine retained the synochal character as long as the febrile symptoms continued, in all the eleven cases. In three of these cases which terminated fatally, it continued in this state to the last.

During the period of desquamation the urine is either normal or anæmic. Becquerel states that although the urine during desquamation after variola resembles, in its chemical constitution, the urine during desquamation after varicella, it differs in respect to colour, the former being of a greenish, the latter of a yellowish tint. According to Schönlein, in the first stage of variola it is of a reddish brown tint; on the third or fourth day a sweat of a peculiar and strong odour is observed, and the urine contains a turbid, apparently purulent, mucous sediment, of an unpleasant odour.

During the period of suppuration sediments, and frequently purulent mucus, are thrown down.

In the nervous form of variola the urine is even more changeable, being sometimes spastic, and sometimes dark. In the putrid form the urine appears decomposed, ammoniacal, and not unfrequently of a dark red colour from the presence of hæmatin.

Scrofulosis.

The urine of children with the scrofulous diathesis differs considerably in the majority of cases from the normal secretion. It is usually pale, but if there is much vascular excitement it becomes more or less deeply coloured; its specific gravity is lower than in a state of health, and in many cases it is much more acid than the urine of children is generally observed to be; it has, however, been found neutral.[1] I have found the urine of rickety children only slightly acid, and once, after it had been passed some hours, it had an alkaline reaction. There are differences of opinion with regard to the nature of the free acid; some state that it is phosphoric acid, others hydrochloric acid, while others, again, are of opinion that it is lactic acid. The urea and uric acid are frequently found to exist in a diminished proportion; on the other hand, the salts, especially the phosphates, are increased; moreover, we not unfrequently find in the urine of scrofulous children an acid which is foreign to the normal organism, viz. oxalic acid.

According to Schönlein, the principal chemical changes in the urine of scrofulous persons consist in the diminution of the

[1] Stark Allg. Patholog. p. 1147.

nitrogenous constituents,—the urea and uric acid, and in the appearance of the non-nitrogenous oxalic acid, and occasionally but more rarely of benzoic acid. The acids are frequently so abundant that the urine, upon cooling, deposits copious sediments of the oxalates, and these sediments sometimes form renal and vesical calculi within the organism itself. The frequent occurrence of oxalate-of-lime or mulberry calculi in children is well known; indeed, Prout is of opinion that half the stone-cases occur before the full age of puberty.

Becquerel has examined the urine in many cases of scrofula, in some of which it showed itself in the form of caries, necrosis, &c.; while in others it appeared in suppuration of the glands. A number of these children were in an anæmic state, while others were apparently in good condition; in the former cases the urine was anæmic, in the latter it was normal. The specific gravity varied from 1010 to 1022. The lowest specific gravity occurred in the anæmic cases. The colour was lighter than that of normal urine, and was frequently of a greenish tinge; the degree of acidity varied extremely, the urine frequently becoming alkaline after a very short time. No uric-acid sediments were observed, either spontaneous, or after the addition of an acid. When febrile symptoms were combined with those of scrofula, the urea approximated to the inflammatory type; its specific gravity became higher, (the average of twelve cases being 1026,) the colour deeper, it had a very acid reaction, and threw down a sediment of uric acid.

In scrofulosis of the osseous tissue or rachitis the urine varies very much in its composition from the normal type. These deviations principally consist in the diminution of urea and of uric acid, and in the increase of the salts. The colour of the urine is generally either pale, or else it differs but little from the normal appearance; the free acid sometimes increases to an extraordinary degree, and some (Fourcroy) maintain that it is free phosphoric acid. The phosphates exceed the physiological average, and moreover a considerable sediment of oxalate of lime is by no means rare. This extraordinary and morbidly-increased capacity of the kidneys for the removal from the blood of those salts which are so essential for the structure of the osseous tissue, and the consequent tendency to the formation of calculi in rachitic children, is regarded by Walther as a

vicarious act of the kidneys in connexion with the formation of bone.

The urine of a child aged 5 years, who was being treated for rachitis in Romberg's clinical ward for children, was sent to me for analysis. It was of a pale yellow colour, turbid, and neutral; its specific gravity was 1011. As the determination of the salts was the principal object that I had in view, it was allowed to stand for two days before the analysis was undertaken; hence the determination of the urea may not have been perfectly accurate. The urine in the other analyses was passed by children aged 3 and 4 years respectively. It was much about the same colour as, or perhaps rather darker than in the first case, was slightly acid, and the specific gravity varied from 1015 to 1020.

The proportion of the most important constituents was found as follows:

	Anal. 124.	Anal. 125.	Anal. 126.	Anal. 127.
Water	978·40	968·50	964·90	962·80
Solid constituents	21·60	31·60	35·10	37·20
Urea	3·50	6·70	6·17	7·36
Uric acid	[1]	0·26	0·35	0·26
Fixed salts	8·53	8·60	14·71	16·70
Phosphate of soda	2·82	4·01	4·27	3·74
Sulphate of potash	1·90	1·80	1·31	1·80
Earthy phosphates	0·48	0·52	0·58	—

On calculating the ratios of these constituents to 100 parts of solid residue, and comparing them with those that occur in healthy urine, we find that the quantity of urea has considerably decreased, while that of the salts is increased. In analyses 124, 126, 127, the increase of the fixed salts is very considerable, especially of the phosphate of soda and earthy phosphates. In analysis 125 this increased ratio is less striking. 100 parts of solid residue contain:

	Anal. 124.	Anal. 125.	Anal. 126.	Anal. 127.	Normal Urine.
Urea	16·1	21·2	17·6	19·8	39·0
Uric acid	—	0·8	1·0	0·7	1·5
Fixed salts	39·4	27·3	41·8	44·8	25·0
Phosphate of soda	13·0	12·7	12·1	10·0	10·0
Earthy phosphates	2·2	1·6	1·6	—	1·5
Sulphate of potash	8·7	5·7	3·8	4·8	8·0

[1] The uric acid was not determined.

In order, however, to arrive at a correct conclusion from these figures we must bear in mind that the urine of children naturally contains a less proportion of urea and of salts than the urine of adults.

In osteomalacia the urine is much the same as in rachitis; it is very acid, and often contains an excessive amount of earthy phosphates.

[Marchand[1] analysed the urine of a child with osteomalacia three days before its death. The fluid was invariably acid, and contained in 1000 parts:

Water	938·2
Solid constituents	61·8
Urea	27·3
Uric acid	0·9
Lactic acid and lactates	14·2
Phosphates of lime and magnesia	5·7
Other substances, and loss	13·7

The earthy phosphates in this instance are five or six times as abundant as in health. In one of the cases recorded by Mr. Solly,[2] there was found in the urine between three and four times the amount of phosphate of lime that occurs in the healthy secretion.]

Tubercular pulmonary phthisis.

In tubercular phthisis the urine varies in accordance with the progress of the disease and the degree of fever which is present. I have observed in the majority of cases that after the febrile symptoms have become continuous the urine has assumed the inflammatory type; that is to say, it is not so deeply coloured as at the height of acute inflammation, but is of a yellowish brown colour, has a tolerably acid reaction, and is above, or at any rate attains the ordinary specific gravity.

In the early stages of the disease I have not found the urine to differ much either in colour, density, or acidity from the normal secretion. I have only observed that form of urine to

[1] Lehrbuch der physiolog. Chemie, p. 338.

[2] Transactions of the Medico-Chirurg. Society, p. 448, 1844.

which the term anæmic has been applied when considerable hæmoptysis has occurred in the second or third stage. After hæmoptysis the urine is generally turbid, and for the first day or two throws down slight sediments of urate of ammonia; it afterwards becomes pale and clear, and continues acid, gradually returning to its normal state. When the febrile symptoms become continuous and the colliquative stage has fairly commenced, I have found the urine approximate in its composition to the urine of inflammation.

Becquerel has examined the urine in a great number of phthisical cases. When the disease is progressing beyond the first stage, the urine is often of higher specific gravity, darker, and secreted in less quantity than usual,—a symptom that the tubercles are extending, and that a state of continuous fever is supervening. The subsequent phenomena of the morning sweats and colliquative diarrhœa further contribute to the concentration of the urine. When, however, a state of decided asthenia has been brought on by these extraordinary drains upon the system, it rapidly assumes opposite properties, and becomes anæmic. Thus the urine of a woman, in whom the tubercles were beginning to soften, and who had at the same time certain symptoms of disease of the heart, was found by Becquerel to amount to 20 ounces in twenty-four hours. It was of a deep yellow colour, threw down a sediment of uric acid, had a specific gravity of 1022·2, and 1000 parts contained 36·5 of solid residue.

In a woman in the third stage of phthisis with great prostration of strength, the urine, three days before her death, was of a deep colour, acid, and threw down a spontaneous sediment. The specific gravity was 1014·7, and 16·2 ounces were discharged in twenty-four hours. 1000 parts contained:

Water	975·95
Solid constituents	24·05
Urea	9·00
Uric acid	1·25

In another precisely similar case the urine, three days before death, was of a deep colour, acid, and threw down a sediment spontaneously. The specific gravity was 1014·7, and there were only 7·2 ounces passed in twenty-four hours.

1000 parts contained 24·25 of solid residue, of which 9·01 was urea, and 2·2 uric acid. In the first of these cases the urea amounted to 37·4% of the solid residue, and the uric acid to 5·1%; in the second the urea amounted to 37·2%, and the uric acid to 9%,—proportions which, as far as the amount of urea is concerned, approximate to those of inflammatory urine.

An analysis of the urine of a man aged 30 years, who was in the colliquative stage of tubercular phthisis, gave very similar results, except as regards the specific gravity.

The urine was brown and turbid, had a very acid reaction, and deposited a purulent-looking yellow sediment of urate of ammonia. The specific gravity was 1026·6.

1000 parts contained:

	Analysis 128.
Water	935·92
Solid constituents	64·08
Urea	23·90
Uric acid	2·40
Fixed salts	10·85

Of these 10·85 parts of fixed salts 1·3 were earthy phosphates, and the sulphates formed only a small part. The urea amounted to 37·3%, and the uric acid to 3·7% of the solid constituents, the urea being as nearly as possible the same as in Becquerel's analyses.

The increase of uric acid is of great interest; it is particularly striking in Becquerel's analyses: other observers have noticed this fact in adults suffering from tubercular phthisis, and Schönlein, moreover, has directed attention to it.

[I am indebted to Dr. Golding Bird for the following case. A man aged 24 years, in the early stage of phthisis, (tubercular depositions but no cavities,) passed in the course of twenty-four hours, forty-five ounces of urine of specific gravity 1020.

The water amounted to	19125 grains.
The solids	936
Urea	328·5
Uric acid	4·5]

In renal and vesical phthisis the urine contains a greater or less quantity of pus.

It is usually pale, turbid, and very quickly takes on an alkaline odour, especially in phthisis vesicæ, in which, even on

emission, it is ammoniacal, and of an unpleasant odour. The pus is sometimes mingled with blood. That the clear filtered urine always contains albumen may be shown by the addition of nitric acid, or by the application of heat.

The urine immediately on its discharge is turbid, but on being allowed to rest, the pus separates in a clearly-defined layer at the bottom; on shaking, it easily mixes again with the urine, and if that fluid have an alkaline reaction the pus becomes tough and fibrous. Pus-corpuscles may be detected by the microscope, and if the urine has an alkaline reaction they will be mixed with crystals of the ammoniaco-magnesian phosphate and with an amorphous precipitate of phosphate of lime.

In order to determine with certainty whether a urinary sediment consists of mucus or of pus, urine which has been just discharged should be examined: the rapid descent of the pus-corpuscles from urine which is turbid at the period of its discharge, and the formation of a sediment which is frequently discoloured, or mixed with blood, together with the presence of a considerable amount of albumen in the urine, leave no doubt respecting the diagnosis. (See page 202.)

Diabetes mellitus.

In diabetes mellitus it is well known that the urine undergoes a very peculiar change; it contains a certain quantity of sugar which, in its ultimate constitution is perfectly identical with grape-sugar, and in consequence of which the urine possesses the property of deflecting the polarized ray to the right. Diabetic urine differs moreover in its physical relations from the normal secretion; it is paler, has a turbid wheyish appearance with a greenish tinge, and a higher specific gravity,—according to Willis, from 1025 to 1055.

Henry drew up a table for the determination of the solid constituents of diabetic urine by the mere application of the urinometer. The results, as far as my experience goes, come sufficiently near to the truth to give fair approximate values to the solid residue from the specific gravity. G. O. Rees recommends the table, having confirmed it by his own experiments; I have somewhat extended its limits, and shall give it here.

Spec. grav. at 60°.	Solid residue in 1000 parts.	Spec. grav. at 60°.	Solid residue in 1000 parts.
1005	11·7	1028	69·1
1006	14·2	1029	71·5
1007	16·7	1030	73·9
1008	19·2	1031	76·4
1009	21·7	1032	78·8
1010	24·2	1033	81·4
1011	26·7	1034	83·9
1012	29·2	1035	86·4
1013	31·7	1036	88·8
1014	34·2	1037	91·3
1015	36·7	1038	93·8
1016	39·2	1039	96·3
1017	41·7	1040	98·7
1018	44·2	1041	101·2
1019	46·7	1042	103·7
1020	49·2	1043	106·2
1021	51·6	1044	108·7
1022	54·1	1045	111·1
1023	56·7	1046	113·6
1024	59·1	1047	116·1
1025	61·6	1048	118·7
1026	64·0	1049	121·2
1027	66·5	1050	123·6

[In my paper[1] on the specific gravity of the urine in health and disease (founded on 200 observations), I have shown that Christison's formula, $\Delta \times 2{\cdot}33$, gives more correct results than the above table. Δ indicates the excess of the specific gravity over 1000. Thus, supposing it is desired to ascertain the amount of solid matter in 1000 parts of urine whose specific gravity is 1035, Δ is here represented by 35, and $35 \times 2{\cdot}33 = 81{\cdot}55$, the required number.]

According to Schönlein there is no sugar in the urine in the first stages of the disease, but albumen; and as the albumen subsequently disappears the formation of sugar in the urine commences.

The quantity of urine increases in an extraordinary degree. P. Frank mentions a case in which fifty-two pounds were discharged during twenty-four hours. According to Bouchardat,

[1] Lancet, June 15, 1844.

the average quantity discharged in the course of the day amounts to from ten to seventeen pounds.

Opinions regarding the composition of the urine are very contradictory, and sufficient analyses have not yet been instituted to enable us to regard any one view as positively correct. Some assert that as the sugar increases in the urine the urea and uric acid decrease, while others maintain that although the absolute quantity of urea in a given amount of urine is actually diminished, yet that on account of the large quantity of urine discharged, the amount of urea is not less than, and in fact exceeds the normal average.

Thus M'Gregor shows that the urine of twenty-four hours in one case of diabetes contained 1013 grains of urea; in another case he found 945 grains, in a third 810 grains, and in a fourth 512 grains, whereas, according to the same authority, the quantity excreted by a healthy person in twenty-four hours does not exceed from 362 to 428 grains. Kane also found in diabetic urine as large a proportion of urea as in the normal secretion. My own analyses certainly tend to show that the ratio of urea to the solid residue is always much less than in health, and that this ratio is diminished in proportion to the increase in the quantity of the sugar; bearing in mind, however, the increased secretion of urine, it is very possible that in some cases the urea is not absolutely diminished: the apparent connexion between the urea and the sugar may then be simply explained by the mere increase of the sugar, which, by increasing the solid residue, causes a relative diminution of the urea.[1] The same is probably the case with respect to the uric acid; when no crystals of uric acid are separated after the addition of free hydrochloric or nitric acid to diabetic urine, the cause may lie in the proportion

[1] In connexion with this subject, we may refer to the experiments of Henry. On mixing the residue of six quarts of diabetic urine with the residue of one quart of healthy urine, and adding nitric acid, only a small quantity of nitrate of urea was obtained after the mixture had stood for twenty-four hours; and on mixing the residue of eight quarts of diabetic urine with that of one quart of healthy urine, and treating it in a similar manner, not a crystal of nitrate of urea could be observed after it had stood for forty-eight hours. Hence it is indispensably requisite that the sugar should be first removed (as completely as possible) before we attempt to determine the urea.

of water being so large as to retain the uric acid in solution. I have frequently observed this to be the case, for on the addition of free hydrochloric acid to the urine no uric acid has been separated, when upon treating that portion of the residue of the urine which is insoluble in alcohol with nitric acid, I have always obtained the red colour which is characteristic of uric acid. Becquerel, however, has observed a spontaneous sediment of uric acid thrown by diabetic urine.

[In this country a sediment of uric acid is by no means rare; I have observed it in at least six cases, usually in the form of bright yellow lancet-shaped crystals.]

I have observed cases in which I have convinced myself that the absolute quantity of urea was diminished.

A man aged 52 years, treated for diabetes mellitus in our hospital did not pass more than from two to two and a half quarts of urine in the twenty-four hours. In its external appearance it was perfectly normal; it contained, however, 8·6% of sugar, and only 0·026% of urea, so that while a healthy man excretes about an ounce of urea in the twenty-four hours, in this case there were only thirteen grains excreted in an equal time. In another man who was being treated by Dr. Lehwess, and who indulged freely in sugared drinks, the quantity of urine in twenty-four hours amounted to between four and five quarts, and contained mere traces of urea. The urine was very pale and turbid, its specific gravity was only 1018, and it contained 4·2% of solid residue, 3·9 of which were sugar. After the discontinuance of the sugar, and the adoption of a proper diet, the specific gravity became lower and the urine contained as much urea as constituted a fifth part of the solid residue: the sugar had also decreased to one half its original amount. Subsequently the sugar almost entirely disappeared from the urine; the urea, on the other hand, had increased to such an extent as to constitute a third part of the solid residue.

Bostock is of opinion that diabetes mellitus is not unfrequently preceded by a diseased condition, (in fact a kind of diabetes,) during which a large quantity of urine very rich in

urea is excreted. As the diabetes becomes developed the urea gradually diminishes as the sugar increases.

Willis[1] states that the urine is occasionally rather turbid on emission, and has then been found to contain a quantity of albuminous matter in the caseous form.

According to Schönlein the urine during the early stage of diabetes contains albumen, and in proportion to its increase the urea diminishes: in the second stage the albumen disappears either totally or partially, and sugar takes its place. I have only detected albumen in two cases of diabetic urine, viz., in the case to which I have already referred, in which I analysed the urine at a time when the patient took a good deal of sugar in his drink; in this case, however, the disease had made considerable progress: and in the urine of a girl a few days before her death; in this instance it existed in considerable quantity, amounting to 0·2% of the urine, or 3·7% of the solid residue.

Brett[2] found casein and butter in a case of diabetic urine.

Diabetic urine sometimes contains an insipid species of sugar, which, however, according to Bouchardat,[3] corresponds in all other properties with the ordinary sweet diabetic sugar, possessing the capability of fermenting, and being convertible by acids into sweet sugar. I have had only one opportunity of observing sugar of this nature.

A girl with diabetes mellitus discharged an abundant quantity of very saccharine urine, and the sugar which was obtained from it had all the properties of grape-sugar. Subsequently the strength of the patient, which had been long giving way, decreased to such an alarming extent as to cause apprehensions of her speedy dissolution. Two days before her death the urine was again sent to me for examination; and I was not a little surprised to find in it a perfectly tasteless sugar soluble in hot spirit, and mixed with a considerable quantity of a gummy matter insoluble in spirit which, on the application of heat, emitted a peculiar odour not unlike that of burned paper.

The salts in diabetic urine are stated by Gueudeville, Bostock,

[1] Urinary Diseases and their Treatment, p. 200.

[2] London Medical Gazette, July, 1836.

[3] Revue Médicale, 1839.

and Henry, to be diminished, while they retain their normal proportion to each other. I have found the amount of earthy phosphates not much below the normal average.

Lehmann[1] was the first who directed attention to the occurrence of hippuric acid in diabetic urine: it has since been detected by Ambrosiani, Müller, and very recently by myself. I obtained it in the same manner as Lehmann did, from the etherial solution of the dried residue: after evaporation there remained a slight brownish-yellow residue, in which, with the help of the microscope, I observed heaps of long acicular crystals. The residue was warmed with a few drops of a weak solution of potash, which neutralized the acid reaction, and the solution was then filtered. On the addition of a solution of perchloride of iron a cinnamon-yellow precipitate was obtained, which on being warmed contracted itself into red flocculi.

On allowing diabetic urine to stand for a considerable time a sediment forms which consists for the most part of fermentation-globules. If the urine above this sediment is allowed to remain for some time longer at a suitable temperature, it begins to undergo fermentation. I have frequently observed the fermentation-globules, and have represented them in fig. 35.

I have made several minute analyses of the urine in diabetes mellitus. The three following analyses were made with the urine of a man aged 50, to whose case reference has been previously made. The first analysis was made at a time when the patient indulged freely in sugared drinks. The urine then contained a mere trace of urea. After the patient had been properly dieted for some time, I obtained the urine for the second analysis, which in its results differs very little from the first. Eight days from this time I again analysed it, and found that the sugar had almost entirely disappeared.

About three months afterwards I received some more of his urine for analysis; it was then very rich in sugar, while urea was present to only a very small amount. Albumen was only detected in the urine of the first analysis. Uric acid was always present, but only in very small quantity.

[1] Journ. für prakt. Chem. vol. 6, p. 114.

	Anal. 129.	Anal. 130.	Anal. 131.
Specific gravity	1018·00	1016·00	1007·00
Water	957·00	960·00	982·00
Solid constituents	43·00	40·00	18·00
Urea	traces	7·99	4·63
Uric acid	traces	a trace	a trace
Sugar	39·80	25·00	a trace
Extractive matter and salts	2·10	6·50	8·60
Earthy phosphates	0·52	0·80	1·00
Albumen	was present.		

The urine of the first two analyses was of a pale-yellow colour, and slightly acid; in the third case it was as clear as water, and produced no change on test paper.

The two following analyses were made with the urine of a girl aged 20 years, who was being treated for diabetes mellitus in Prof. Wolff's clinical wards.

The first analysis was made eight weeks before the second; I made an analysis of the blood at the same time. (See Analysis 42, Vol. I, page 327.)

The second analysis was made two days before death; it revealed the fact that the diabetes sapidus had changed into diabetes insipidus; moreover, at this period, the urine contained a considerable quantity of albumen.

	Analysis 132.	Analysis 133.
Specific gravity	1032·00	1021·00
Water	921·85	947·20
Solid constituents	78·15	52·80
Urea	0·54	1·47
Sweet sugar	72·00	—
Insipid sugar	—	27·61
Extractive matter and salts	4·20	2·80
Earthy phosphates	0·92	0·40
Albumen	—	2·00
Gummy matter	—	17·30

Analysis 134 was made with the urine of a man aged 52 years, who was being treated in Schönlein's clinical wards for diabetes. The urine was not passed in very large quantity, but it contained a remarkably large proportion of sugar. The composition of the blood, which also contained sugar, is given in Analysis 41, Vol. I, page 327.

	Analysis 134.
Specific gravity	1036·00
Water	909·60
Solid constituents	90·40
Urea	0·26
Uric acid	a trace
Sugar	86·30
Extractive matter and salts	2·10
Earthy phosphates	1·50

I have recently had an opportunity of making a careful examination of the excretions of a diabetic patient. He was a man aged 40 years, who had suffered from intense thirst and had observed a great increase in the amount of his urine for the preceding ten months. At the period of his admission into the hospital, the colour of his urine was normal, and an acid reaction always observed, which, however, became more decided some time after emission: in the course of ten or twelve hours it usually became turbid, and deposited a light viscid sediment consisting of amorphous urate of ammonia and mucus-corpuscles; on two occasions (during the use of a very animal diet) crystals of uric acid were noticed in the sediment. During the period of my investigations I never detected albumen in the urine. The specific gravity varied from 1039 to 1030. It was highest at the commencement of the treatment.

On admission the daily amount of urine averaged nearly five quarts, but while under treatment it was reduced to three quarts. The daily amount of sugar gradually diminished to one third, but was never so thoroughly reduced as to afford hopes of a permanent cure. The daily excretion of urea was at first much diminished, but subsequently reached the healthy average. Uric acid was always present, but not in so considerable a quantity as would have been found in the urine of healthy persons living on a similar diet. The amount of fixed salts varied considerably, but was always larger than in a state of health.

After the use of the ordinary hospital diet for a few days, he was placed on a very nitrogenous diet, consisting of beef-tea, eggs, meat, milk, and white bread. Subsequently coffee was substituted for the milk, and the amount of bread diminished. And still later gluten-bread containing only one-half the amount of starch, but three times the amount of nitrogenous matter, was given in its place.

During his last three weeks he consumed daily, one pound of gluten-bread, two of beef from which a quart of beef-tea had been made, besides a quarter of a pound of ordinary boiled beef, three or four ounces of roast veal, six eggs, and two quarts of coffee prepared from an ounce of the beans. Although this quantity was (according to his own statement) sufficient to satisfy his hunger, he was occasionally detected in appropriating the farinaceous diet of other patients. With regard to medical treatment, opium and its various compounds were first given;

he was then treated with astringents, the nitrogenous diet being at the same time increased, and the saccharine and farinaceous matters diminished. After this course had been pursued for some time without any decided benefit, he took daily two ounces of cod-liver oil, and after this had been continued for twelve days, he took, additionally, four grains of iodide of iron. Finally, (these medicines being continued) the gluten bread was ordered, and the milk and white bread stopped. Under this treatment the daily amount of sugar fell from twelve ounces to seven and three-quarters; it subsequently, however, rose to nine ounces and one drachm. The urea, which on his admission amounted to only three drachms in twenty-four hours, was now increased to one ounce and three drachms, and the uric acid rose from a mere trace to twelve grains.

During this course of treatment the digestion seemed good, the thirst diminished, and he occasionally perspired considerably; he had become, however, very emaciated. The saliva was slightly alkaline, and I examined it for sugar unsuccessfully. Sugar was, however, detected in the perspiration. The analysis of his fæces will be found in Chapter X.

In the determination of the sugar and urea there are certain difficulties which I shall briefly notice. On treating diabetic urine evaporated to the thickness of a syrup with warm spirit, the mucus, uric acid or urates, and earthy phosphates are precipitated. On evaporating the filtered spirituous solution to the consistence of a thin syrup, and adding anhydrous alcohol, an insoluble semifluid mass separates, which, when repeatedly treated with anhydrous alcohol, becomes finally thick and tough. On dissolving this saccharine mass in warm spirit, and again precipitating it by anhydrous alcohol, it will still be found to contain a certain amount of urea; in fact, I have detected urea after the operation has thrice been effected, and I find that sugar can only be obtained free from urea by allowing it to crystallize spontaneously from its spirituous solution. In consequence of the difficulty of separating these substances, I proceed in the following manner: the solid residue of the urine is first accurately determined; a weighed portion of urine is then evaporated, mixed with spirit, and the solution filtered. The filtered solution is evaporated to the consistence of a syrup, and, when cold, mixed with a sufficient quantity of concentrated

nitric acid to allow of a few drops remaining on the surface of the crystalline mass. It must then be submitted to a low temperature, and the crystals placed on blotting paper and compressed till they cease to communicate moisture. The fixed salts must be determined from a seperate portion of urine. If we deduct from the known quantity of solid residue the portion insoluble in spirit (from which the uric acid is determined), the urea, and the fixed salts, we obtain, as the difference, sugar and alcohol-extract which appears to decrease in diabetic urine in proportion as the sugar increases. The following are the special results of my analyses of the urine of this man.

No. 135 represents the analysis of the urine before the commencement of the animal diet; No. 136, shortly after its commencement; No. 137, during the same diet, shortly before the use of the cod-liver oil; No. 138, after the oil had been taken for eight days; No. 139, after the iodide of iron had been used for eight days; No. 140, after the gluten-bread had been tried for eight days; No. 141, two days subsequently to the preceding analysis, there being a considerable increase in the secretion.

In twenty-four hours there were discharged:

	Anal. 135.	Anal. 136.	Anal. 137.
	4½ quarts	3 quarts	4 quarts
Specific gravity . .	1037·1	1038·9	[illegible]
Solid constituents . .	14·5 oz.	9·9 oz.	10·0 oz.
Sugar and extractive matter . .	12·5 „	7·5 „	8·5 „
[illegible] . . .	3 drachms	5 drachms	7 drachms
Uric acid . .	—	5 grains	8 grains
Fixed salts . .	—	—	6 drachms

	Anal. 138.	Anal. 139.	Anal. 140.	Anal. 141.
	4 quarts	4 quarts	3½ quarts	4½ quarts
Specific gravity . .	1030·2	1030·4	1032·37	1032·97
Solid constituents .	10·5 oz.	10·5 oz.	10·2 oz.	12·5 oz.
Sugar and extractive matter . .	8·9 „	7·25 „	8·1 „	9·6 „
Urea . . .	7·8 drs.	10·0 drs.	1·1 „	1·3 „
Uric acid . .	10 grs.	—	5 grs.	15 grs.
Fixed salts . .	6 drs.	8 drs.	6·8 drs	1 oz. 9 grs.

The composition of the urine appears from my observations to undergo a rapid modification as soon as there are decided indications of convalescence. The sugar decreases to a very

great extent, and is replaced by albumen, a substance of frequent occurrence at the commencement of the disease, and apparently alternating with the sugar.

When the sugar is no longer perceptible to the taste (either in the urine or in the spirit-extract), it can always be readily detected by Trommer's test. I usually take a test-tube of about seven inches in length, fill three fourths of an inch of it with urine, and heat it with ʒss or ℈ij of carbonate of potash; I add five or six times the volume of spirit of ·845, and again boil; a few drops of a solution of sulphate of copper are then added, and heat again applied. If much sugar is present, the reduction of the oxide of copper to a state of sub-oxide occurs very quickly in the lower stratum of solution of carbonate of potash, and the fluid becomes of a yellow, red, or copper colour; if the quantity of sugar is very small, the reduction still takes place, but much more gradually. If, however, no sugar is present, the solution of potash remains of a blue or blueish-green colour.

I have recently analysed a specimen of diabetic urine containing only a very small amount of sugar, although previously that constituent had been present in large quantity. A short time previously to the last analysis, no sugar could be detected, but albumen was present. The urine passed at different periods of the day was analysed separately. The quantity of urine passed between noon and evening contained most sugar, and was most abundant; that passed during the night contained the least. The three analyses gave the following results:

	Anal. 142. Urine from Noon till Evening.	Anal. 143. Urine during the Night.	Anal. 144. Urine from early Morning to Noon.
Quantity of urine	34·3 oz.	6 oz.	10·7 oz.
Specific gravity	1026·02	1024·38	1027·76
In 1000 parts there were contained:			
Water	943·00	946·43	934·47
Solid constituents	57·00	53·57	65·53
Urea	14·12	17·50	16·21
Uric acid	0·34	0·80	0·50
Chloride of sodium, with a little carbonate and sulphate of soda	11·27	8·60	10·50
Alkaline sulphates and phosphates	5·80	4·65	5·70
Earthy phosphates	1·20	0·80	0·90
Extractive matters, with ammonia-salts and traces of sugar	24·51	21·94	32·18

The whole amount of the different constituents discharged in twenty-four hours was as follows:

Solid constituents . . .	3 oz.
Urea	365 grs.
Uric acid	11·2 grs.
Fixed salts	425 grs.
Extractive matters . . .	1 oz. 139 grs.

[The following analysis of diabetic urine has been made by Dr. Reich.[1] The particulars of the case are not recorded:

Water . . .	907·88
Solid constituents . .	98·12
Urea . . .	8·27
Hippuric acid . .	0·04
Sugar . . .	56·00
Water-extract . .	5·60
Alcohol-extract . .	16·36
Mucus . . .	0·54
Albumen . . .	0·58
Chloride of potassium . .	0·30
Chloride of sodium . .	0·84
Chloride of ammonium .	0·66
Sulphate of potash . .	0·26
Phosphate of soda . .	2·15
Phosphate of lime . .	0·46
Silica . . .	0·86

The hippuric acid was determined by evaporating the urine to one eighth of its volume and treating it with hydrochloric acid, when that constituent was thrown down as a white deposit.

An instance in which diabetic urine occurred in a state of extraordinary concentration has been observed by Bouchardat. Its composition is given below. The three other analyses were made by Dr. Percy; the cases are fully recorded in the London Medical Gazette for 1844.

	Bouchardat.		Percy.	
Spec. grav.		1042·00	1035·00	10·39
Water . .	837·58	894·50	918·30	898·90
Solid constituents .	162·42	105·50	81·70	101·10
Urea . .	8·27	12·16	30·32	2·39
Uric acid .	—	0·16	0·26	not isolated
Sugar . .	134·42	40·12	17·15	79·10
Extractive matters and salts	20·34	53·06	32·59	19·52
Earthy phosphates .	0·38		1·30	0·09]

Lehmann[2] has made two minute analyses of diabetic urine; he found neither albumen, urea, nor uric acid in it, but a

[1] Simon's Beiträge, p. 545. [2] De diabetica urina. Dissert. inaug.

considerable amount of hippuric acid. The urine of a man aged 18 years had a specific gravity of 1029·5, was pale, when fresh, had a milky smell, and subsequently became acid. The solid constituents amounted to 62·05, of which 58·15 were sugar. Ether took up 0·187, which was chiefly hippuric acid. The urine of a man aged 38 years was turbid, of a straw colour, contained neither albumen, urea, or uric acid, had a specific gravity of 1028·5, and contained 56·24 of solid constituents, of which 50·9 were sugar. There were also found 0·31 of hippuric acid, 0·169 of salts soluble in alcohol, 0·21 of water-extract, 0·39 of salts soluble in water, 0·31 of salts insoluble in water, and 0·23 of mucus.

An interesting case of diabetes in a girl aged 8 years was observed by Cantin.[1] The urine which she discharged was of a blue colour, and impregnated with sugar. The colouring matter appeared to possess the properties of Prussian blue.

Diabetic urine has been observed in children as well as in adults, and during the period of puberty.

The female sex is not exempt from this disease.

It is impossible in the present state of our knowledge on this subject to state with certainty in what part of the system the sugar is formed, which is produced and excreted in such extraordinary quantity. It is either directly formed in the chylopoietic system or it is produced in the peripheral vascular system, or it is generated by a morbid action of the cells of the kidney, or finally its origin may be due to a combination of these agencies.

To decide this point satisfactorily, (and for the science of medicine it is most important that it should be decided,) the following points should first be established by experiments on a sound and certain basis:

(1.) Is the correspondence of the absolute diminution of the urea with the absolute increase of the sugar, an invariable rule?

(2.) May not the nitrogen be removed from the system in some other way, probably in the form of ammonia-compounds?

(3.) Do the other secretions undergo a change, especially the bile?

(4.) Does the air which is exhaled from the lungs differ in its composition from that which is expired by healthy persons?

[1] Journ. de Chim. Méd. vol. 9, p. 104.

(5.) Do the kidneys, liver, or lungs undergo any changes? and if so, what is their nature?

If the connexion between the appearance of the sugar and the diminution of the urea is constant, that is to say, if, without exception, the urea invariably decreases in the same ratio as the sugar increases, then we must assume with Berzelius, that in place of the metamorphosis of the protein-compounds into urea which occurs as a normal process, these compounds are in this case, from certain causes which are unknown to us, transformed into sugar, ammonia, and perhaps into nitrogenous extractive matters. This hypothesis is, however, opposed by the facts which were observed by M'Gregor: in his cases the daily secretion of urea equalled, and in fact exceeded the healthy average.

It has been established by the researches of Rollo, Bouchardat, myself, and others, that the blood really contains sugar. It exists, however, in an extremely minute quantity, and my own observation confirms the remark of Bouchardat, that it is most abundant a short time after meals: the blood of a girl in whom the disease had made considerable progress, when taken before a meal, exhibited a mere trace of sugar. Hence we are led to infer that the formation of sugar occurs in the chylopoietic viscera alone, or there and in the blood simultaneously.

From experiments made by M'Gregor,[1] he infers that the sugar is formed in the stomach alone. After having convinced himself of the existence of sugar in diabetic blood by having induced fermentation, he sought for, and found it in the matters vomited both by a healthy man and a diabetic patient, three hours after dinner. Upon treating the healthy man and the diabetic patient with an initiatory course of emetics and purgatives, and then for three days feeding them with nothing but beef and water, no sugar was found in the matter vomited by the healthy man, whilst there was still sugar in the other case. M'Gregor also found sugar in the fæces of diabetic patients: no sugar was, however, found in the sweat. It is well known that persons with this disease do not readily perspire; on the contrary the skin becomes dry, rough, and peels

[1] London Med. Gaz., May 1837.

off. Willis[1] relates a case of diabetes that fell under his own observation, in which the furfuraceous exfoliation of the cuticle had a decidedly sweet taste.

From pathological anatomy we learn that the kidneys in death from diabetes are very frequently softened, and according to Meyer (who refers the formation of sugar to the kidneys), even disorganized, their blood-vessels much enlarged, and the substance of the papillæ and the tubuli very permeable; the kidneys have also been found inflamed, atrophied, suppurating, and containing calculi. The condition in which the liver has been found is also various: the bile is, however, usually very far from being in a normal condition; it is of a pale yellow colour, very fluid, and, instead of being alkaline, has usually an acid reaction. The veins which form the portal system are overloaded, and the mesenteric vessels are generally congested. As the disease becomes further developed the lungs participate in the general disturbance, for, according to Willis, pulmonary phthisis is the immediate cause of death in two thirds of the cases of diabetes. Traces of morbid action have also been found in the nervous system.

It is of great importance in reference to the ætiology of diabetes mellitus to ascertain whether the changes which are revealed to us by the prosecution of the morbid anatomy of the disease, are consequences of the disease itself, or whether they had a previous existence in those blood-metamorphosing organs, the kidneys, liver, and lungs, and whether the formation of the sugar is due to them.

The questions which I have already suggested are of much importance in elucidating these points.

Taking into consideration all that is known of the origin of diabetes mellitus, it appears very probable that the sugar is formed not in any single organ, but that it is produced by a diseased condition of the whole system, and we are almost led to adopt the opinion expressed by P. Frank, that a specific influence is exercised upon the nerves of the fauces by a spontaneously-generated *virus diabeticum*, which occasions an insatiable

[1] Urinary Diseases and their Treatment, p. 205.

desire for drink, and at the same time exerts a peculiar influence upon the nerves of the lymphatic system, exciting them to extraordinary activity.

This activity of the lymphatic system, when associated with an excessive absorption from all the secreting surfaces of the body causes the premature elimination of raw and unassimilated chyle, which, not being adequate to the formation of blood, must be again removed from it. When we consider what an extraordinary quantity of sugar is carried off, even in those patients who are restricted to animal food, we cannot doubt that the sugar is formed from the protein-compounds,[1] and in all probability, future and more accurate analyses of the urine, the bile, and the expired air, will enable us to understand in what manner the nitrogen is removed from the system, a point upon which we are at present in the dark. For although we can well conceive the possibility of the protein-compounds being, under peculiar circumstances, resolved into sugar of grapes, and certain nitrogenous compounds similar to protein itself, yet these latter must be capable of being detected.

Periodic symptoms have been occasionally observed in diabetes mellitus.

A physician in Berlin has a patient who, at certain times of the year, had periodical attacks of diabetes mellitus, which after continuing for some time, and with the application of proper diet, would disappear: although the amount of sugar which was excreted during these attacks was by no means inconsiderable, the patient did not exhibit that meagerness which usually succeeds a prolonged continuance of the disease; on the contrary, he became corpulent, and complained of no disturbance of his general health.

Diabetes insipidus.

Under the term "diabetes insipidus" are included several diseased states, in which the urinary secretion is very much increased, but where the urine contains no sugar, either sweet or insipid, which is capable of fermentation. Willis

[1] [Budge's views on this subject may be seen in my Report on the recent progress of Animal Chemistry, in vol. 2 of Ranking's Half-yearly Abstract.]

treats of these different states under the heads Hydruria, Anazoturia, and Azoturia.

Hydruria, which is also known as diuresis, polyuresis, and polydipsia, seems to be capable of continuing sometimes for several years, without being accompanied by any other morbid symptoms than a frequent desire to micturate, and an insatiable thirst. Willis mentions several cases of the kind: amongst others, that of an artisan 55 years of age, who from his sixteenth year had upon an average drunk nearly two pailsful daily, and who, during the same period, passed on an average thirty-four pounds of urine and one of fæces. The urine was scarcely denser than pure water and contained no sugar.

A similar case is recorded of a woman aged 40 years, who from her infancy experienced constant thirst, and an enormous secretion of urine. She enjoyed good health, and was the mother of several children.

Becquerel observed a case of polydipsia or hydruria in a servant girl aged 23 years. After recovering from an attack of acute nephritis she lapsed into a state of anæmia, for which ferruginous medicines were exhibited, but without success. A continuous state of thirst then came on; so much so, in fact, that she daily took five or six litres of fluid without allaying the sensation. The urine was very pale and greenish, was rather turbid from the presence of mucus, and had an acid reaction. Its specific gravity was 1006, and about six pounds were excreted in the course of the day.

Its composition was as follows:

Water	989·7
Solid constituents	10·3
Urea	3·0
Uric acid	0·2
Fixed salts	3·6
Extractive matters	3·7

[L'Heretier[1] has published an analysis of urine very similar in its character. The patient was a pregnant woman. She discharged about ninety-five ounces daily, and the specific gravity was 1009·4.

[1] Traité de Chim. pathol. p. 553.

It contained in 1000 parts:

Water	989·7
Solid constituents	10·3
Urea	3·3
Uric acid	0·2
Fixed salts	3·2
Organic matters	3·6

I am indebted to Dr. Golding Bird for the following analysis of the urine in polydipsia. A woman aged 43 years observed that, in the course of four months, the amount of urine rose from the normal quantity to 140 ounces. The specific gravity was 1010.

The whole quantity of water amounted to	60419 grains
" solids "	1439 "
Urea	376 "
Uric acid	21 "
Fixed salts	462 "]

When this diuresis occurs in nervous persons at an advanced age, Willis observes that it should not be regarded lightly, as the prognosis is almost always unfavorable.

By anazoturia, Willis understands the excessive secretion of urine very deficient in solid constituents and especially in urea, and he considers that all the cases of diabetes which have been reported as cured may probably be classed under this head. The urine is passed in very abundant quantity, and is either of a pale straw colour or entirely colourless, and has a very slight odour. It has either a very mild acid, or else a neutral reaction; in the course of twenty-four hours it becomes ammoniacal, and forms a precipitate, at the same time becoming covered with a film containing crystals of ammoniaco-magnesian phosphate. This disease seems common amongst the children of the poor, who have been brought up on an improper diet. In a child treated by Willis the urine was perfectly devoid of colour, its specific gravity was that of distilled water, and 1000 grains left, after evaporation, a residue of scarcely one grain, which consisted of mucus, urate of ammonia, phosphates, and a trace of urea.

A man, who for many years had suffered from a sensation of extreme weakness, thirst, and gnawing pain in the region of the heart, discharged from six to seven quarts of urine daily: it was almost devoid of odour, of a pale straw colour, and one thousand parts left a solid residue of twenty, of which only two were urea.

A case of the same nature was treated by Stosch. A man who complained of pain in the cardiac region, thirst, and weakness, passed from four to six quarts of urine daily; it contained no sugar, and scarcely a trace of urea or of the other ordinary constituents of urine.

By the term azoturia Willis understands that form of disease which is usually known as diabetes insipidus, in which the urine is increased in quantity, is usually transparent and pale, but sometimes deeply coloured, and is peculiarly distinguished by the large amount of urea which it contains. The urine has a slight, but at the same time an urinous odour, an acid reaction, and its specific gravity (1018—1035) is higher than in the preceding form of disease. When the density is considerable, crystals of nitrate of urea are often yielded on the addition of nitric acid, after a few hours' rest, without any previous concentration.

The general symptoms are the same as in the former varieties: loss of strength, feeling of weakness, gnawing pains in the region of the heart, thirst, &c. An artisan thirty-seven years of age, (treated by Willis,) contracted the disease in consequence of a cold, and passed a large quantity of pale urine, amounting to about five quarts daily. The specific gravity varied from 1022 to 1028. On the addition of nitric acid to the urine at its highest degree of density, crystallization of nitrate of urea occurred in a few hours. 1000 grains left, on evaporation, 72 of solid residue, of which 51 were composed of urea, alcohol-extract, and salts soluble in alcohol; 14 were hydrochlorates and sulphates; 6 were earthy salts, especially phosphates; and 1 grain consisted of mucus. Willis is of opinion that this form of diabetes frequently precedes diabetes mellitus, or alternates with albuminous or saccharine urine.

[Dr. Golding Bird analysed the urine of a fine, but emaciated man aged 35 years, who stated that his brother had died of diabetes. The urine in twenty-four hours amounted to 50 fluid ounces, and had a specific gravity of 1030.

The water amounted to	20956	grains
Solids	1574	„
Urea	757·95	„
Uric acid	6·75	„]

In diabetes chylosus the urine contains a very large quantity of albumen and fat, so as to give it almost a milky appearance. I have already alluded in general terms to this form of urine, and I have only further to add that, according to Chevallier, it comes on after the use of mercury, and, associated with hæmaturia, is endemic in the Isle of France; it has also been several times observed in Europe.

Willis remarks that these disturbances in the renal secretion frequently occur without causing any degree of constitutional disease, and often without any detriment whatever to the general health. Slightly removed from this form of urine, is that in which a protein-compound approximating to a modification of casein, or where actual milk (milk-metastasis,) is discharged with the urine.

We have lastly to mention a form of chylous urine in which fibrin and albumen, but no blood-corpuscles, are discharged.

Abernethy observed urine of this sort in a woman, and Prout has described several cases. It coagulates spontaneously, and forms a mass which, as Abernethy remarks, might be served up at table for blanc-mange.

Dropsy.

During dropsical affections the urine often differs considerably from its normal state. Its quantity is generally less than in a state of health, and it presents various peculiarities in quality. It is sometimes dark, very acid, rich in uric acid, and, according to Schönlein, in urea also; sometimes it contains blood; in other cases it is pale and opalescent, resembling anæmic urine, and not unfrequently containing a considerable amount of albumen; but this substance is by no means invariably present in the urine of dropsy.

In hydrothorax the urine, according to Schönlein, is secreted scantily; it is of a dark purple red colour, and presents a fiery appearance; during the approach of recovery it becomes more abundant, and, especially when the disease is complicated with inflammation of the pleura or lung, throws down precipitates of a reddish-yellow or brick-dust colour, which are frequently mixed with purulent mucus.

In chronic hydrothorax, a thick, fiery-red urine is generally

passed, which speedily deposits a considerable sediment of a brick-dust or rose-red colour; in some few cases a clear, transparent urine, like that which is passed in spasm, is discharged in tolerable abundance.

I have analysed the urine of a man who was suffering both from hydrothorax and cavities in the lungs. It was deeply coloured, had a strong acid reaction, contained no albumen, and formed a slight sediment of urate of ammonia.

Its specific gravity was 1025. Its composition was as follows:

	Analysis 145.
Water . . .	936·54
Solid constituents . .	63·46
Urea . . .	22·17
Uric acid . . .	0·53
Fixed salts . . .	12·60
Earthy phosphates . .	0·36
Extractive matter . .	26·80

In ascites inflammatorius the urine is secreted in diminished quantity, is of a dark red or brownish colour, and not unfrequently contains blood in a state of solution, or blood-corpuscles; the latter may be recognized by the microscope, and if the urine is allowed to stand, they form a red sediment; frequently, however, no hæmatoglobulin but merely albumen is present. On the approach of recovery, there is, according to Schönlein, a copious discharge of urine, accompanied by a purulent, and subsequently a mucous sediment.

At the commencement of chronic ascites the urine is not much diminished in quantity; it assumes a pale or opalescent shining green colour, and contains a large quantity of albumen and mucus.

Persons suffering from periodic ascites pass a small quantity of red, turbid urine, which sometimes deposits very copious sediments of uric acid and urate of ammonia. Towards convalescence, the discharge of urine becomes very abundant, and it continues to throw down copious lateritious sediments. The occurrence of a clear, slightly coloured, spastic urine, without these critical sediments, must be regarded as an unfavorable symptom, since it indicates renal "colliquation." (Schönlein.)

In those varieties of ascites that arise from affections of the liver, spleen, stomach, and generative organs, the amount of urine is

also diminished. It appears either of a dark red or brown colour without sediments, (as when the ascites arises from disorganization of the female generative organs, or of the pancreas,) or it throws down copious lateritious or fawn-coloured sediments, (as in diseases of the liver, spleen, or vena portæ;) sometimes it is coloured with bile as in jaundice. (Schönlein.)

Becquerel likewise observed that the urine in ascites arising from disease of the liver, is scanty, highly coloured, and almost always throws down a dark or reddish sediment of uric acid.

In dropsy from disease of the heart the urine, according to Becquerel, assumes various phases; it may be pale or highly coloured, clear or turbid, with or without sediments, and may or may not contain albumen. He also observes that in the advanced stage of hypertrophy of the heart there is a state of hyperæmia induced in some other organs, especially a good deal of congestion of the kidneys, much as occurs in the first stage of Bright's disease, which causes a change in the elimination of the urine from the blood, and accounts for the transitory presence of albumen, the same as we observe in severe inflammatory affections.

When the dropsical symptoms are consequent upon disease of the heart alone, the urine, according to Becquerel, is not so much changed as when hepatic disease, (especially cirrhosis,) is associated with it: it is then scanty, deeply coloured and often reddish, very acid, of high specific gravity (1025—1029), and usually throws down a copious reddish sediment of uric acid and urate of ammonia.

When the dropsy arises from the combined influence of an affection of the heart and Bright's disease, the urine ordinarily assumes the special characters of the latter disorder, which have been already described. If, however, the disease of the heart causes much functional disturbance, the urine becomes deeply coloured, more acid, and deposits a sediment.

When the dropsy arises solely from disease of the kidneys, the urine is always albuminous: the majority of these cases fall under Bright's disease, which has been already noticed. I examined the urine of a young man 22 years of age, in a far advanced stage of ascites, and whose subsequent dissection revealed suppuration of the kidneys. The urine was pale, turbid,

slightly acid, contained much albumen, and deposited a sediment, which was shown by the microscope to consist of pus- and mucus-corpuscles: its specific gravity was 1026.

It contained:

	Analysis 146.
Water	935·50
Solid constituents . . .	64·50
Urea	18·20
Uric acid	1·10
Albumen and pus-corpuscles . .	18·60
Alcohol-extract with ammonia and lactic acid	12·35
Water-extract . . .	4·60
Fixed salts from the extractive matters .	6·20

The amount of urea was much diminished, being only 27% of the solid residue, whereas the normal average is 39%.

On the other hand, I found a very appreciable quantity of urea in the dropsical fluid, obtained by puncturing the abdominal parietes.

Nysten analysed the urine of a man aged 18 years, who had been suffering from ascites for several months. There were only 8 ounces of urine excreted in twenty-four hours; it was turbid and of a reddish colour, very frothy, and when allowed to stand, deposited a white flocculent sediment. It had an ammoniacal odour, a strong alkaline reaction, and contained hardly a trace of urea; but a considerable quantity of colouring matter and albumen were found in it, and more salts than in healthy urine of digestion.

Graves also observed a considerable quantity of carbonate of ammonia in the urine of a labourer who was suffering from ascites, anasarca, and a tympanitic condition of the intestinal canal, urea being almost entirely absent.

In a case of ascites arising from peritonitis, which was only fully recognized on dissection by the changed condition of the peritoneal surface, a small quantity of urine was discharged, which was of a dark colour, and on cooling threw down a considerable lateritious sediment.

[Heller[1] analysed the urine of a woman aged 40 years, suffering from ascites. The secretion was tolerably copious, of a light yellow colour, and turbid from containing a large quan-

[1] Archiv für phys. and pathol. Chemie, vol. 1, p. 47.

tity of mucus. It was neutral but speedily became alkaline. Its specific gravity was 1007, and it contained in 1000 parts:

Water	978·40
Solid constituents	21·60
Urea	8·40
Uric acid	mere traces.
Extractive matter and traces of albumen	7·11
Fixed salts, chiefly chloride of sodium	6·00]

In anasarca the properties of the urine appear to vary; it frequently contains albumen in abundance,[1] while on other occasions there is not a trace of it.

Becquerel relates the case of a girl 9 years of age, who, after being exposed to a sudden and violent chill, was attacked with anasarca on the following day. The skin was hot, and the pulse feverish; after a short time peritoneal effusion came on, but the urine contained no trace of albumen. It was deeply coloured, of high specific gravity, and frequently deposited a uric-acid sediment.

In five cases in which anasarca succeeded general debility (dropsy from anæmia,) Becquerel found the urine very pale, of low specific gravity (from 1009 to 1012,) and of a greenish tint. In one case he found a little albumen.

Graves[2] relates a case in which a labourer, after getting chilled, suffered much from fever and anasarca. The urine was pale, straw-coloured, very ammoniacal, and formed a sediment of earthy phosphates; it contained scarcely a trace of albumen. Willis, on the contrary, with hardly an exception, found the urine albuminous when the anasarca arose from cold.

[Scherer[3] examined the urine of a man with anasarca succeeding a severe attack of broncho-pneumonia, from which he was recovering. The urine contained blood. After taking

[1] Rayer, Bright, and Christison are of opinion that when albuminous urine occurs with anasarca, it is a certain indication of incipient organic change in the kidney, while on the other hand Blackall and Graves regard the appearance of albumen as a consequence of a general inflammatory diathesis. Becquerel adopts an intermediate view; he attributes the appearance of albumen in the urine in inflammatory affections to a transitory congestion of the cortical substance, similar to that which is found in the first stage of Bright's disease.

[2] Urinary Diseases and their Treatment, by R. Willis, M.D., p. 126.

[3] Untersuchungen, &c., p. 48.

inf. senegæ for four days the hæmaturia ceased. The secretion was then analysed; its specific gravity was 1022, and it contained in 1000 parts:

Water	966·2
Solid constituents	33·8
Urea	18·5
Uric acid	0·9
Lactic and extractive matter	6·4
Soluble salts	5·2
Earthy phosphates and mucus	1·8]

In our observations on scarlatina we remarked that in the anasarca which so frequently succeeds that disease, the urine sometimes contains albumen, and sometimes is free from it.

In ovarian dropsy the urine, according to Schönlein, is very scanty; it contains a large quantity of albumen, which increases in amount as the disease advances.

Jaundice.

In jaundice, whether it be idiopathic or symptomatic, the urine contains bile-pigment, which shows itself in the peculiar colour which it communicates to that fluid. But it sometimes also contains other constituents of the bile, for I have detected biliary resin in icteric urine, and Gmelin found cholesterin in a case in which the flow of bile was impeded.

The colour of icteric urine may vary from a saffron-yellow to a yellowish-brown, brownish-red, or blackish-brown; if there is any doubt whether the colour is produced by biliphæin, we must adopt the steps described in page 192, which will readily determine the point. The presence of bilifellinic acid may sometimes be detected by the taste, and always by the directions given in page 193.

The specific gravity of icteric urine is variable: it depends, (as do the proportions of the ordinary normal constituents,) upon the relative state of the organism, upon other complicating diseases, and upon the absence, presence, or degree of vascular disturbance.

In acute icterus accompanied by fever, Schönlein found the urine at first of a dark red or brown colour from the presence of bile-pigment; it afterwards became gradually darker, and at last as black as ink.

It continued, however, transparent, and did not form sediments till the crisis.

A servant girl in our hospital, aged about 20 or more years, presented a case of inflammatory icterus. The skin was of a brown-yellow colour, the tinge on the face and breast being particularly dark: the pulse was feverish, especially towards the evening; the mental faculties disturbed and delirium during the night.

The urine was of a brown, almost a blood-red colour, (thin strata appearing of a deep saffron tint,) it had a powerful acid reaction, and deposited a very abundant brownish-yellow sediment, which consisted partly of crystallized uric acid coloured by biliphæin, and partly of urate of ammonia coloured in a similar manner. The specific gravity of this urine was 1020. It contained:

	Analysis 147.
Water	954·50
Solid constituents	45·50
Urea	12·34
Uric acid with biliphæin	2·90
Alcohol-extract	4·35
Spirit-extract	5·29
Water-extract, mucus, and bile-pigment	5·14
Biliary resin	1·45
Biliverdin	1·08
Earthy phosphates	3·14
Chloride of sodium and lactate of soda	2·61
Alkaline sulphates and phosphates with traces of chloride of sodium	3·90[1]

This analysis presents several points worthy of consideration. The urea is much below the normal average, amounting to only 27% instead of 39% of the solid residue. The uric acid is much increased, for it amounts to 6·3%, whereas the normal average is only 1·5%; it must, however, be remembered that the uric acid from a very considerable sediment of urate of ammonia has been included, and that a certain amount of bile-pigment was associated with it. The fixed salts are below the normal average, amounting to only 19%, the earthy phosphates on the other hand amount to 4·9%.

[1] The biliary resin and biliverdin were taken up by anhydrous alcohol with the urea and alcohol-extract. On evaporating the alcohol and adding water, the biliary resin and biliverdin were precipitated; this latter was separated from the resin by digestion in a weak solution of ammonia, which on evaporation left the green colouring matter.

An analysis of the blood of this person has been given in Vol. I., page 330.

In common or chronic icterus, where, instead of there being febrile symptoms, the pulse becomes slower as the disease advances, the urine is at first of a dark red colour, after a time it becomes of a dark brown, and often, according to Schönlein, of an inky tint; towards convalescence it clears up, and gradually returns to the normal state.

I made an analysis of the urine of a man suffering from icterus, anasarca, and hæmoptysis, who was being treated in our hospital.

This analysis corresponded closely in its results with the preceding one.

The urine was of a brownish red colour, very turbid, had an acid reaction, and deposited two layers of sediment, the under one of a lateritious appearance, and the upper of a brown colour; both consisted of urate of ammonia coloured partly with uroerythrin and partly with biliphæin. The urine became perfectly clear on being heated, and at the boiling point gave no indications of albumen. Nitric acid caused no precipitate, but produced the well-known shades of colour dependent on the presence of bile-pigment. The specific gravity was 1014.

The urine contained:

	Analysis 148.
Water	962·80
Solid constituents	37·20
Urea	10·90
Uric acid	1·01
Urate of ammonia	3·51
Fixed salts	6·70
Earthy phosphates	0·74

The urea in this case amounts to only 29% of the solid residue, and the uric acid independently of the urate of ammonia to 2·7%, the latter alone amounting to ·9%: the salts are diminished, with the exception of the earthy phosphates which are increased and amount to 2%.

[Scherer[1] mentions a case of long-standing icterus, dependent apparently on chronic inflammation of the parenchyma of the liver, in which the urine, on emission, was clear, yellow, and perfectly neutral, but after standing three or four hours became

[1] Untersuchungen &c. p. 59.

acid and deposited uric acid combined with a large amount of bile-pigment as an amorphous, yellowish-brown, flocculent mass. The development of the acid (lactic, according to Scherer) proceeded rapidly, and in the course of twenty-four hours the yellow colour of the urine became converted into a blackish green. The deposition of the sediment and the change of colour could be more speedily induced by the addition of a few drops of acetic or hydrochloric acid to the fresh urine. The specific gravity was 1018, and in 1000 parts there were 42·5 of solid résidue, including only 4·3 parts of urea, while there were no less than 1·8 of uric acid. In the course of ten weeks he had much improved, and was able to take exercise in the open air. The solid constituents were then reduced to 35·6, and the uric acid to 0·6, while the urea rose to 12·4. The urine of this patient contained a large quantity of silica.]

Hysteria.

In attacks of hysteria the urine is often, but not invariably, remarkable for its clear limpid appearance, and for the extremely small quantity of solid constituents which it contains: in fact, it is sometimes very like common water.

Becquerel observes that, in nervous attacks, the urine is not always spastic and secreted in large quantity, but that it sometimes resembles the normal secretion, and in certain cases he even found it deeply coloured, of high specific gravity, loaded with uric acid, and occasionally depositing a sediment.

He observed similar variations in the urine at the commencement of an attack of hemicrania.

Nysten mentions an analysis of nervous urine, which was perfectly limpid, had an acid reaction, contained more urea than the urina potûs, but, on the other hand, less uric acid and salts. According to Rollo, urea and the organic constituents are wanting in spasmodic urine, and it contains only the ordinary salts.

In cramp of the stomach, Gmelin found the urine darker than usual; it contained bile-pigment, which was, however, somewhat modified, since on being precipitated with hydrochloric acid, and being again dissolved in potash, it gave a beautiful red with nitric acid, without previously going through the green and blue tints.

Marasmus senilis.

[Scherer[1] has published an analysis of the urine in a case of marasmus senilis accompanied with gangrene.

It contained in 1000 parts:

Water	927·45
Solid constituents	72·55
Urea	17·52
Uric acid	1·70
Alcohol-extract	13·23
Water-extract	15·00
Soluble salts	20·00
Earthy phosphates	4·67

The amount of soluble salts and earthy phosphates is remarkably large.

A man aged 29 years, labouring under marasmus from sexual abuses, was observed by Dr. Golding Bird to pass daily thirty-six ounces of urine of specific gravity 1024.

The water amounted to	15227 grains.
The solids	901
Urea	369·6
Uric acid	36·0]

Carcinoma.

The urine in scirrhus ventriculi is, as Berzelius has remarked, sometimes turbid, has a milky look when it is discharged, and deposits a white sediment of mucus and phosphate of lime; Fromherz and Gugert also found mucus and earthy phosphates in the urine of a person who was liable to frequent vomiting in consequence of scirrhus of the pylorus; the urine was alkaline from the presence of carbonates of soda and ammonia, and contained no uric acid, but much urea.

In opposition to these statements I found the urine secreted in small quantity, deeply coloured, without a sediment, and with a very acid reaction, in an advanced case of scirrhus ventriculi, occurring in a man in Schönlein's clinical ward, who vomited matter like coffee-grounds.

[1] Untersuchungen &c. p. 75.

Four days afterwards, when the vomiting was partially checked by the use of morphia, the urine was turbid and jumentous: it continued acid, and subsequently formed a copious sediment of urate of ammonia, while the clear urine above the precipitate was so dark that bile-pigment was suspected to be present, which, however, was not the case. The urine continued to throw down sediments till the death of the patient, which occurred not long afterwards; it became, however, of a brighter colour.

Becquerel observes that in cancer of the stomach he has found the urine normal, when there has been but little functional disturbance: dark, sedimentary and very acid, when there has been severe pain and frequent vomiting: and, finally, he has found it anæmic in cases in which the physical powers have been reduced to the lowest ebb by the disease.

In cancer of the liver, Becquerel found the urine undergo the same modifications that I have described as occurring in cancer of the stomach. It was very dark, very acid, of high specific gravity (1023—1026), and threw down a copious red sediment.

In cirrhosis of the liver, Becquerel found the urine much the same as in cancer, except that when the cirrhosis was accompanied by icterus, bile-pigment found its way into the urine.

[I am indebted to Dr. Percy for the following analysis of the urine of a man labouring under deep and permanent jaundice consequent on true carcinoma of the liver, of which he died.

The urine contained in 1000 parts:

Water	979·00
Solid residue	21·00
Urea	3·76
Indeterminate organic matter	8·78
Salts soluble in water	8·18
Salts insoluble in water	0·28

It was deeply tinged with bile-pigment, but deposited no sediment.

The small amount of urea may be accounted for by the fact of great emaciation consequent on long previous mal-assimilation, and the small amount of metamorphosis of tissue occurring in the patient.]

Syphilis.

[Heller examined the urine of a man aged 38 years, who was taking iodide of potassium for a syphilitic eruption accompanied with pains in the bones. When the urine was first examined he was taking two scruples daily in three ounces of distilled water; on the second occasion (four days afterwards) he was taking additionally half a grain of iodine.

	1.	2.
Specific gravity	1015	1021
Water	974·800	954·40
Solid constituents	25·200	45·60
Urea	7·736	13·82
Uric acid	0·310	0·51
Extractive matters and hydrochlorate of ammonia	6·433	12·15
Fixed salts, including iodide of potassium	10·520	19·32

The urine on the first occasion was excreted in about the normal quantity, was of a dark-yellow colour, and had an acid reaction: on the second occasion it was of an intensely dark-yellow colour, and its reaction was faintly alkaline; its amount was also diminished. No albumen or biliphæin was present in either case.

After the continuance of the second prescription for eight days, the urine of twenty-four hours was collected with the view of ascertaining the amount of iodine removed by the kidneys. The whole daily urine amounted to 850 grammes or 24·5 ounces.

In order to estimate the amount of iodine, 200 grammes of urine were evaporated, the residue dissolved in water, and ammonia added to the filtered solution till it exhibited a strongly alkaline reaction. On the addition of nitrate of silver a precipitate was thrown down which was washed with a weak solution of ammonia, dried, and weighed.

From the 200 grammes of urine 0·94 of iodide of silver were obtained, containing 0·507 of iodine; hence 1000 parts of urine contained 2·535 of iodine, corresponding to 3·322 of iodide of potassium. Consequently, in the whole daily amount of urine there were contained 2·824 grammes or 38·689 grains of the iodide.

Now the 40 grains of iodide of potassium and half grain of iodine may be regarded as equivalent to 40·626 grains of the iodide alone (for iodine is always in a state of combination when it occurs in the secretions), and consequently the whole of the iodide was removed by the kidneys, with the exception of nearly two grains which were distributed partly to the saliva, sweat, nasal mucus, &c. and partly remained in the blood.]

Skin-diseases.

[The urine in a case of urticaria tuberculosa has been analysed by Scherer. The patient was a young man who likewise suffered from rheumatism. The urine was discharged in very small quantity, often not more than five or six ounces in forty-eight hours. It was clear, of a brownish-red colour, very acid, and its specific gravity was 1028.

It contained in 1000 parts:

Water	931·58
Solid residue	68·42
Urea	30·46
Uric acid	0·74
Alcohol-extract with much lactic acid	21·24
Water-extract	4·92
Alkaline salts	8·03
Earthy phosphates	2·02

The most remarkable points in the constitution of the urine are the large amount of earthy phosphates, and the excess of free acid.

Heller[1] has published three analyses of the urine in cases of herpes zoster.

1. A boy aged 8 years; eruption on the right side, no fever, urinary secretion abundant. The urine was of a pale yellow colour, rather turbid, rapidly became putrid, and deposited a sediment of beautifully-formed crystals of ammoniaco-magnesian phosphate.

The urine was faintly alkaline on emission, and its specific gravity varied from 1014 to 1015.

[1] Archiv, vol. 1, pp. 39-43.

It contained in 1000 parts:

Water	970·00	
Solid constituents	30·00	
Urea	8·94	
Uric acid	traces	
Fat	0·14	
A little extractive matter with a large amount of hydrochlorate and carbonate of ammonia	9·32	
Fixed salts	11·60	
consisting of:		
Earthy phosphates	2·000	
Chloride of sodium	4·154	
Sulphate of potash	0·164	
Phosphate and carbonate of soda, &c.	5·282	

No trace of hippuric acid could be discovered.

2. A man aged 31 years; eruption on right side, slight fever. Urinary secretion considerably suppressed, the urine analysed being the first that had been passed for twenty-four hours. In a few hours it formed a sediment of ammoniaco-magnesian phosphate and urate of ammonia.

It was strongly alkaline, and its specific gravity was 1028.

It contained in 1000 parts:

Water	944·40	
Solid constituents	55·60	
Urea	15·79	
Uric acid with a little urate of ammonia	1·80	
Fat	0·34	
Extractive matters with much hydrochlorate and carbonate of ammonia	21·35	
Fixed salts in the sediment	0·43	16·75
Fixed salts in the urine	16·32	
consisting of:		
Earthy phosphates	2·85	
Chloride of sodium	5·10	
Sulphate of potash	0·15	
Phosphate of soda, &c.	8·24	

3. A young man aged 19 years; eruption chiefly on left side, no fever. The urine was very clear. In the course of twelve hours it became turbid and deposited beautiful crystals of ammoniaco-magnesian phosphate. Specific gravity 1018.

The urine contained in 1000 parts:

Water	958·90
Solid constituents	41·10
Urea	14·20
Uric acid	0·20
Fat	0·12
Extractive matters, much hydrochlorate of ammonia, &c.	12·14
Fixed salts	14·44
consisting of:	
Earthy phosphates	2·60
Chloride of sodium	5·40
Sulphate of potash	0·08
Phosphate and carbonate of soda, &c.	6·36

From these analyses we may conclude that in herpes zoster the chief peculiarities of the urine are:

1. A marked increase of the chlorides and phosphates, and a corresponding diminution of the sulphates.

2. An excess of hydrochlorate of ammonia.

3. A large amount of fat.

4. A diminution in the amount of uric acid. An increase only occurs when the disease is accompanied with fever.

The presence of oxalate of lime may always be suspected in these cases.

The urine in a case of pompholix has also been analysed by Heller. The patient was a woman aged 40 years; the attack was very severe and proved fatal. The urine deposited a light cloudy sediment consisting principally of mucus, but also containing fat-globules, urate of ammonia, and a few epithelium-scales. It was acid, and its specific gravity was 1017·5.

It contained in 1000 parts:

Water	955·80
Solid constituents	44·20
Urea	24·63
Uric acid	0·58
Extractive matters	11·79
Fixed salts	7·20

Of the fixed salts the earthy phosphates were normal, the sulphates much increased, and the chloride of sodium proportionally diminished. The urea is considerably above the normal average.]

ON SOME OTHER MODIFICATIONS OF THE URINE INDUCED BY DISEASE.

Fat in urine.

There are certain morbid conditions in which fat is excreted in a free state with the urine, which, at the same time, is neither chylous nor milky, nor contains any large amount of albumen or casein. Urine of this sort most commonly occurs in those diseases in which there is a very rapid loss of substance and force. I have on several occasions detected fat in the urine of phthisical persons, and on two occasions I have found it during tabes. I have already (see page 190) explained in what manner the presence of fat may be detected with certainty; I would here add a word of caution, that the presence of fat from extraneous sources, as improperly cleaned glasses, &c. must be carefully guarded against.

Such cases as that which is related by Bachetoni,[1] in which a noble young lady is reported to have discharged two ounces of olive oil with the urine on different occasions, must at least be regarded as mysterious; Elliotson[2] also witnessed the daily discharge of about one third of an ounce of oil with the urine of a woman suffering from biliary calculi.

[A case of fatty urine has been recently described by Dr. Golding Bird (Urinary Deposits, page 263.) An analysis of this form of urine has likewise been given in page 229 of this Volume.]

Milk in urine.

In speaking of diabetes I adverted to chylous urine, and said a few words regarding milky urine. It appears from an essay of Rayer, in which he enters fully into the subject, that this form of morbid urine is extremely rare; but that the term 'milky urine' has frequently been applied incorrectly to the

[1] Comment. Bonon. Pars I, ad ann. 1787.

[2] On the discharge of fatty matters from the alimentary and urinary passages. (Medico-Chirurg. Transactions, vol. 18, p. 80.)

fluid simply from its having a turbid or emulsive appearance, while there has been no trace of casein, but the fat has been suspended by means of albumen.

The only recorded case of actual milky urine containing casein and fat are one by Canubio, of a woman who was suckling; one by Alibert, of a healthy young widow; and, lastly, a case by Graves.

Excess of hippuric acid in urine.

[There are certain conditions of the system in which an excess of hippuric acid occurs in the urine, independently of those cases in which benzoic or cinnamic acid is taken either in the food or as medicine.

The following case is recorded by Bouchardat.[1]

A lady aged 53 years, suffering from lassitude, dry skin and tongue, occasional pain in the region of the liver, loss of appetite, and great thirst, passed a large quantity of limpid urine possessing an odour of whey. Its specific gravity varied from 1006 to 1008; it slightly reddened litmus paper, and contained in 1000 parts:

Water	986·00
Solid constituents	14·00
Urea	1·56
Hippuric acid	2·23
Lactate of soda	2·96
Albumen	1·47
Mucus	0·20
Chloride of sodium	2·75
Phosphate of soda	0·97
Alkaline sulphates	1·44
Earthy phosphates	0·42

Dr. Garrod[2] has narrated the case of a man suffering from pain in the loins and symptoms of atonic dyspepsia, with flabby, white, furred tongue, who excreted a considerable amount of hippuric acid.

When examining the urine for the purpose of ascertaining the proportion of uric acid by the addition of a small quantity of hydrochloric acid, he found the tube filled with crystals of hippuric acid, and on these large crystals smaller ones of uric

[1] Annuaire de Thérapeutique, 1842, p. 285. [2] Lancet, Nov. 16, 1844.

acid were deposited. For several days he found as much as half a drachm in six ounces of urine, or about 10 of hippuric acid in 1000 parts. It afterwards gradually diminished, requiring considerable evaporation before crystals were deposited, and ultimately disappeared. The patient had previously suffered from voiding an excess of urea, and his urine had contained a deposit of ammoniaco-magnesian phosphate.

Dr. Pettinkoffer[1] has also published an analysis of urine containing an excess of hippuric acid. The patient was a girl aged 13 years, suffering from chorea. The urine was limpid and acid on emission, but soon became alkaline and deposited crystals of ammoniaco-magnesian phosphate. After pouring nitric acid on the evaporated alcoholic extract with a view of determining the amount of urea, Dr. Pettinkoffer was surprised to find that instead of the usual crystalline plates of nitrate of urea, brownish yellow needles made their appearance. Under the microscope the needles were found to be six-sided prisms, in some places intermingled with plates of nitrate of urea. The urine evidently contained a large amount of hippuric acid in combination with potash or soda, from which the nitric acid separated it. When the alcoholic extract of the urine was evaporated, mixed with hydrochloric acid, and allowed to stand, four-sided prismatic crystals of hippuric acid were deposited.

1000 parts of urine contained 40·668 of solid residue, of which 31·251 were soluble in spirit, and consisted of hippurates, urea, extractive matters, and chlorides; while the remaining 9·417 were composed of urates, phosphates, and sulphates, together with mucus and water-extract.

The solid residue yielded, on incineration, 10·599 of fixed salts.

On the following day, 1000 parts of urine yielded 49·825 of solid residue and 12·985 of ash, consisting of:

Carbonates of lime and magnesia	1·153	1·866 insoluble in water.
Earthy phosphates	0·713	
Carbonate of soda	3·996	
Chlorides of sodium and potassium	6·181	
Phosphate of soda	0·128	
Sulphate of lime	0·814	

[1] Liebig's und Wöhler's Annalen, vol. 50, No. 1.

If we consider that the alkaline carbonate in the ash corresponds with the hippurate in the urine, then 1000 parts of urine must have contained 12·886 of anhydrous hippuric acid, and 100 parts of solid residue 25·8 of the same constituent. During this period the only food taken by the girl was bread, apples, and water; she, however, gradually resumed her ordinary diet, and the excess of hippuric simultaneously disappeared.]

Urostealith in urine.

[Heller[1] has recently announced the discovery of a new constituent of urinary calculi, to which he has given the name *urostealith*. It is soluble in carbonate of soda; and when that remedy is administered, urostealith in a state of solution is found in the urine.

The patient was a man of tolerably good constitution, aged 24 years; he complained of pain in the region of the right kidney, and difficulty in micturition, occasionally passing small elastic soft concretions. These were examined by Heller, and found to be perfectly soluble in alkalies, with which they formed a soap.

Analysis of the urine before the administration of carbonate of soda.—25th Feb. The urine had a light yellow, whey-like appearance, no odour, and deposited a sediment of ammoniaco-magnesian phosphate. Fat-globules were detected under the microscope. The reaction was neutral; the specific gravity 1017·5. It contained in 1000 parts:

Water	965·800	
Solid constituents	34·200	
Urea	12·631	
Fat	0·320	
Extractive matters with much hydrochlorate of ammonia	8·569	
Fixed salts	12·680	
consisting of:		
Earthy phosphates	2·040	12·680
Chloride of sodium	0·163	
Sulphate of potash	2·296	
Basic phosphate of soda and peroxide of iron	8·181	

Moreover, every 1000 parts of urine threw down 0·62 of pure ammoniaco-magnesian phosphate. Not a trace of uric acid could be detected.

[1] Archiv für phys. und patholog. Chemie, vol. 2, p. 1.

28th Feb. The day after the carbonate of soda had been given, the urine was neutral, of a pale yellow colour, and had a specific gravity of 1006. Fragments of urostealith were detected in the sediment, mixed with ammoniaco-magnesian phosphate. No uric acid was present.

By the 2d of March the calculus of urostealith was almost entirely dissolved. The reaction of the urine was neutral; the addition of ammonia produced a reddish brown tint; (this is regarded by Heller as a test for urostealith;) uric acid was still absent. The specific gravity was 1020. The urine contained in 1000 parts:

Water	959·90
Solid constituents	40·10
Urea	11·20
Fat and urostealith	3·40
Extractive matters and hydrochlorate of ammonia	8·29
Fixed salts	17·21

No sediment was deposited. In order to obtain the urostealith, a large quantity of urine was evaporated, and sulphuric acid added in order to decompose the soap. The urostealith was taken up by boiling ether, which, on evaporation, yielded a violet tint. For further information on the chemical characters of this substance I must refer to Chapter XII.]

Semen in urine.

It may sometimes be of importance to ascertain whether the urine contains any seminal fluid. This point can be best settled by the microscope. We find mucous floccules in the urine; and if semen is present, the spermatozoa will be detected amongst them. They are represented in fig. 33.

Urine of peculiar colours.

Some cases have been recorded in which the colour of the urine has deviated extremely from the normal type. A case is related by Janus Plaucus, in which a dark blue sediment was precipitated from the urine of a man 60 years of age, a short time before his death. He had formerly suffered from

dysuria and vesical calculus, and subsequently from typhus fever.

Marcet, Prout, Braconnot, Babington, Garnier, Spangeberg, and others, have observed blue and black urine. I have related a case in which the urine deposited a blue sediment, in page 274.

I have made an examination of the urine passed by a man at Gräfenberg, who had spent many years in the East Indies, and returned to Europe for the benefit of his health. It had a strong ammoniacal odour, was of a clear blue colour, and deposited a somewhat copious dark blue sediment, which appeared, from a microscopic examination, to consist of very fine amorphous matter (on which the blue colour was dependent) and a few crystals of ammoniaco-magnesian phosphate. On treating a portion of the washed and dried sediment with caustic potash the colour did not disappear; hence it was not dependent on the presence of iodide of starch or prussian blue. Dilute organic acids and hydrochloric acid neither dissolved it nor destroyed its colour; but on digesting it in nitric acid, the tint changed from blue to yellow. Digested in concentrated sulphuric acid, it dissolved, forming a solution of an indigo colour. On warming a portion of the sediment on platinum foil, it first evolved an urinous odour, and subsequently volatilized, going off in deep violet-coloured vapour. The most convincing proof that the blue tint was due to indigo, was that on warming a portion of the sediment with dilute alcohol to which grape sugar and potash had been added, the fluid lost its blue tint, and assumed a yellowish red colour, which, on shaking, was converted into an intense blood-red, and then rapidly into a green. On allowing it to rest the green tint disappeared, and the fluid assumed a yellowish-red colour. All these phenomena led to the conclusion that the colouring matter was indigo. I have since heard that specimens of the same urine were sent to Bouchardat, Liebig, and Prout, who coincide in the opinion that the pigment was not indigo, but a distinct organic compound. No indigo, or indeed medicine of any sort had been recently taken by the patient.

Dulk[1] has observed and analysed black urine passed by a person suffering from derangement of the liver and portal system.

[1] Archiv der Pharmacie, vol. 18, p. 159.

[Dr. v. Velsen[1] has published the case of a man aged 84 years, with chronic cystitis, who passed very fetid urine of a deep violet colour, after the use of lime-water mixed with warm milk. After the omission of the draught for a few days, the peculiar colour disappeared.]

Urine during pregnancy, at the period of delivery, and after delivery.

Since Nauche's announcement (a few years ago) of the discovery of a peculiar substance to which he gave the name of *kystein,* in the urine of pregnant women, the renal secretion during this state has been carefully examined by numerous chemists.

Nauche describes kystein as a white mass that, after the urine has stood for some time, separates, partly rising to the surface, where it forms a somewhat tough pilous membrane interspersed with glistening crystals, and partly sinks to the bottom, forming a creamy precipitate. Nauche regards kystein as an indubitable sign of pregnancy. It is also considered a certain test by Eguiser; he states that it appears after the urine has stood two to six days, depositing itself as a white opaque body, and then rising to the surface and producing a film like the solid fat that settles on cold broth. From an extensive series of observations, Dr. Kane concludes that kystein does not appear sooner than thirty hours, or later than eight days; that on its first appearance it forms a scarcely perceptible membrane, which gradually becomes firmer and thicker, and after a time, breaks up, the fragments sinking to the bottom; that a kystein-like membrane may also appear in the urine of persons with phthisis, arthritis, metastatic abscesses, vesical catarrh, &c. but that it differs from true kystein, both in the manner of its formation and of its destruction; it appears later than the true kystein, but, having once appeared, develops itself more rapidly and possesses less tenacity. The urine is neutral or ammoniacal on the appearance of the kystein, which, under the microscope, appears as an amorphous matter consisting of minute opaque corpuscles, intermingled with crystals

[1] Casper's Wochenschrift, 1844, No. 18.

of ammoniaco-magnesian phosphate. Dr. Kane convinced himself that the occurrence of kystein was independent of the presence of albumen; he likewise ascertained that it occurs not only during pregnancy but also during the period of lactation, especially when the secretion of milk is at all checked. He concludes with the observation that "when pregnancy is possible, the exhibition of a clearly-defined kystein-pellicle is one of the least equivocal proofs of that condition, and that when, in a case of suspected pregnancy, this pellicle is not found, if the female be healthy, the probabilities are as twenty to one that the prognosis is incorrect."[1] It appears from a review of Kane's cases, that the kystein most commonly appears on the third day; in one case, however, it could not be observed till the eighth day after the urine had been passed; and in some cases it appeared during the first twenty-four hours.

During the first weeks of pregnancy, Kane only rarely observed it; it was most commonly noticed during the seventh, eighth, and ninth months, and up to the period of delivery. In eighty-five cases of pregnancy it was absent eleven times, and was present in thirty-two out of ninety-four cases examined during lactation.

I have examined the urine during the second, third, fourth, fifth, and sixth months of pregnancy, but have not invariably detected kystein. In the cases in which it was formed, as in the second, fifth, and sixth months of pregnancy, the urine on emission was clear, yellow, faintly acid, and not affected either by nitric or acetic acid, or by heat. Usually, in about twenty-four hours, the whole urine became slightly turbid, the acid reaction disappeared, a white viscid sediment was deposited, and soon afterwards the surface of the fluid became covered with a pellicle at first extremely delicate, but after from twelve to twenty-four hours becoming tough, thick, opaque, and with a glistening appearance in consequence of the light reflected from numerous minute crystals of ammoniaco-magnesian phosphate with which it was studded. On examining this pellicle in its early state under the microscope, it appeared (when magnified 300 times) to consist of an amorphous matter composed of minute, opaque points, such as are presented by sediments of phosphate of lime or urate of ammonia, except that in the latter the in-

[1] American Journal of Med. Science, July 1842.

dividual particles are usually darker, more clearly defined, and larger than in kystein. The whole field of vision was likewise bestrewed with numerous vibriones in active motion, and crystals of ammoniaco-magnesian phosphate. When the pellicle became thicker, precisely similar phenomena were observed, but the vibriones were supplanted by a considerable number of monads; on the addition of acetic acid the crystals disappeared, while the amorphous matter remained unaffected. On digesting the pellicle in acetic acid, and adding ferrocyanide of potassium to the filtered solution, a comparatively slight turbidity ensued, but on macerating the pellicle in a dilute solution of potash, acidulating the filtered solution with acetic acid, heating, and adding ferrocyanide of potassium after a second filtration, a more decided turbidity was observed. From these experiments I concluded that a protein-compound was present. The white sediment, that occurred after the urine had stood for some days, possessed a disagreeable, pungent, caseous odour: under the microscope it presented the same appearance as the pellicle. After repeatedly washing a portion of the sediment with water, and then heating it with alcohol and a little sulphuric acid, it developed a disagreeable fruit-like odour, reminding me of butyric ether. [We shall presently show that the accuracy of this observation has been thoroughly established by Lehmann.] It results from the above observations, that kystein is not a new and distinct substance, but a protein-compound, whose formation is undoubtedly and closely connected with the lacteal secretion. From the observations of Kane and myself, it seems to follow that pregnancy may exist without the occurrence of kystein in the urine; if, however, there is a probability or possibility of pregnancy, and kystein is found in the urine, then the probability is reduced almost to a certainty. We are unable to draw any positive inferences respecting the stage of pregnancy from the appearance of the kystein.

A deposit of caseous matter and earthy phosphates was frequently observed by Golding Bird in the advanced stages of pregnancy. The sediment is probably similar to Nauche's kystein.

Every urine left to itself forms a pellicle, more or less resembling that of kystein. If formed soon after the urine is discharged, it consists of earthy phosphates, which, from the

urine being alkaline, are, for the most part precipitated, but likewise form a delicate film on the surface. When this is the case, the pellicle is very thin and readily sinks to the bottom. Under the microscope crystals of ammoniaco-magnesian phosphate, and an amorphous matter very similar to kystein, but consisting of phosphate of lime, are observed: this likewise differs from kystein in being soluble in free acids. A pellicle of fat on the surface of urine may sometimes be mistaken for kystein: films of this nature are very thin and usually iridescent, and the microscope reveals the presence of numerous fat-globules.

The membrane formed on the surface of urine six or eight days after emission, usually consists of a species of mould; under the microscope there may be seen innumerable filaments matted together, and interspersed with sporules.

I once observed a pellicle on the surface of a man's urine three days after emission, which both in chemical and microscopical characters presented the closest analogy to kystein.[1]

[Lehmann[2] frequently examined the urine of a pregnant woman from the second to the seventh month. It was of a dirty yellow colour, and more inclined to froth than usual; it generally became turbid in from two to six hours; but the morning urine, after standing for thirty-six or forty-eight hours, was always covered with a grayish-white film, which often, in two or three days, sank and mixed with the sediment that formed when the turbidity appeared, but sometimes was a longer period before it broke up. By means of ether he could always remove from this film a considerable quantity of viscid fat, which formed a soap with potash, and then, on the addition of sulphuric acid, developed a well-marked odour of butyric acid. On treating a large quantity of this urine with sulphuric acid, and distilling, he obtained, after treating the distillate with baryta water, brilliant crystals of butyrate of baryta. The substance taken up by ether, when gently evaporated with nitric acid and exposed to the vapour of ammonia, was not in the least reddened; with concentrated hydrochloric acid, on the

[1] [A similar appearance has been observed by Prout in the urine of a delicate child, fed chiefly on milk. (On Stomach and Renal Diseases, 4th edit. p. 555, note.)]

[2] Lehrbuch der physiologischen Chemie, vol. 1, p. 252.

other hand, it assumed a blue tint; dissolved in potash, boiled, and treated with hydrochloric acid, it developed sulphuretted hydrogen; it dissolved tolerably freely in acetic acid, from which it was precipitated by ferrocyanide of potassium. These reactions left no doubt of its being a protein-compound. The portion of the film insoluble in potash consisted chiefly of phosphate of magnesia, [ammoniaco-magnesian phosphate?] with a little phosphate of lime. Hence Lehmann concludes that the kystein of Nauche is not a new and distinct substance, but a mixture of butyraceous fat, phosphate of magnesia, and a protein-compound very similar to casein. He likewise mentions that, in examining the urine of a woman who was not suckling, and was kept on very low and sparing diet, on the third, fourth, sixth, and ninth days after delivery, he found a large quantity of butyric acid taken up by ether from the solid residue; and on dissolving the ethereal extract in water, adding sulphuric acid, and distilling, he obtained a further quantity. The urine in this case was always rather turbid, of a dirty yellow colour, very acid, and contained a very small amount of uric acid.

Möller[1] relates two cases in which the urine of women who were not pregnant was covered with a film exactly resembling kystein: in one case there was considerable hypertrophy of the uterus; in the other, no affection of the generative organs could be detected. The film of kystein consists, according to his observations, of fat, earthy phosphates, and a caseous matter, which differs, however, from the casein of milk in being held in solution by a free acid. When the urine becomes neutral or alkaline, the caseous matter ceases to be held in solution, and separates as kystein. Everything checking the decomposition of the urine hinders the formation of the pellicle, and if the recent secretion is treated with a free acid (mineral or organic); no separation of kystein takes place even if ammonia be added to saturation, or decomposition allowed to proceed to any extent.

In a case of decided pregnancy, no kystein was formed during the period of a severe cold, attended with a copious deposition of urates; but when the urine became natural, the kystein reappeared. He twice detected cholesterin in kystein.

[1] Casper's Wochenschr. Jan. 11-18, 1845.

Kleybolte[1] has examined the urine in ten cases of pregnancy, and invariably found kystein on the fifth day. The morning secretion was used, and, after being slightly covered to protect it from dust, was allowed to stand, at an ordinary temperature, for ten days. The following appearances were observed in the tenth week of pregnancy: urine peculiarly yellow, with a greenish tint. 2d day, mucous sediment; 3d day, no change; 4th day, turbidity ascending from the bottom; 5th day, white points and leaflets on the surface, turbidity ascending from all parts of the bottom, and the sediment almost gone; 6th day, kystein distinctly observed on the surface, like lumps of fat on the surface of cold broth; 7th day, no change. From the 8th to the 10th day, the kystein disappears, the turbidity again descends, and the sediment noticed on the 2d day is reproduced. The nine remaining cases are in most respects similar to the above.

A few observations on kystein have been recently published by Audouard,[2] but contain nothing of importance, except that in six specimens of urine passed by young women suffering from amenorrhœa, he found kystein in five.[3]]

I shall now give a short abstract of Becquerel's researches. During pregnancy, the general state of the system is liable to great variations, and the urine presents differences of corresponding importance. If good health is enjoyed during pregnancy, the urine remains normal; if, however, anything should happen to excite the vascular system, it readily changes, becoming dark-coloured, acid, sedimentary, and diminished in quantity. During the latter stages of pregnancy the urine often assumes the anæmic type, that is to say, it becomes pale, contains only a small amount of solid residue, and the specific gravity does not exceed 1011. The observations which were communicated by Donné in a letter addressed to the Academy of Sciences, dated May 24, 1841, in reference to the urine in pregnancy containing less free acid, and less of the phosphate and sulphate of lime than normal urine, were not

[1] Casper's Wochenschrift, April 26, 1845. [2] Journal de Chimie Méd. May 1845.

[3] Many other communications have recently been published on this subject, which I do not deem necessary to notice, as they are, for the most part, simply confirmatory of the above observations.

confirmed by Becquerel. Neither could Becquerel observe kystein.

After delivery, mucus, tinged with blood, is mixed with the urine; this is succeeded by the discharge which is known as the lochia. During the period that intervenes between delivery and the commencement of the milk-fever, the urine either assumes the inflammatory type, and is scanty, high-coloured, acid, and dense, as, for instance, in those cases in which the labour has been very difficult and painful, and the vascular system is much excited; or it takes on the anæmic form, as in those cases in which the labour is followed by great debility and prostration.

Becquerel gives two analyses: one was made with the urine of a woman aged 33 years, who, the previous evening, had been delivered of a dead child; pulse 96, strong; urine of a deep red colour, acid, and sedimentary; the sediment was mixed with sanguineous mucus, and there was a little albumen in the urine.

The second analysis was made with the urine of a woman aged 22 years, who had been delivered forty-eight hours previously of a seven months dead child. Pulse 92, rather weak; urine was very red, and held in suspension a cloud of sanguineous mucus and a considerable quantity of albumen.

	1.	2.
Quantity of urine in 24 hours in ounces	30	26·5
Specific gravity . . .	1012·6	1018·0
1000 parts contained:		
Water	979·5	970·2
Solid constituents . . .	20·5	29·8
Urea	6·5	7·8
Uric acid . . .	0·5	0·5
Fixed salts . . .	4·6	7·4
Extractive matters . .	9·5	10·6
Albumen . . .	—	3·3

We see from the ratio of the urea and also of the uric acid to the solid residue, that the urine in neither of these cases can be regarded as inflammatory, but that it rather approximates to the anæmic type. In the first analysis the urea amounts to only 31% and the uric acid to 2·4% of the solid residue; in the second analysis, the former amounts to 27% and the latter to 2%.

In most of the cases in which Becquerel examined the morning urine of women who had recently been delivered, he found it anæmic; the specific gravity varied from 1006 to 1014, the average being 1011.

As the milk-fever comes on, the chemical composition of the urine appears to undergo some modification, at least we are led to infer so from an analysis of Becquerel. It was secreted in diminished quantity, contained a larger proportion of urea and uric acid, was darker, and deposited a sediment.

He examined the urine of a woman aged 22 years, four days after delivery, while suffering from the milk-fever. It was of a saffron-yellow colour, deposited a sediment on the addition of nitric acid, and also spontaneously, after the lapse of some hours. In the course of twenty-four hours there were 15·5 ounces excreted. The specific gravity was 1031·5.

1000 parts contained:

Water	948·2
Solid constituents	51·8
Urea	18·7
Uric acid	2·7
Fixed salts	11·3
Extractive matter	18·3
Albumen	0·7

Here the urea amounts to 36%, and the uric acid to no less than 5% of the solid residue.

On the passage of medicinal and other substances into the urine.

[All substances incapable of assimilation that enter the circulation are removed by the kidneys, either in the state in which they entered the organism, or in a modified condition.

Inorganic, non-metallic bodies. Iodine appears rapidly in the urine in combination with ammonium, (Lehmann,) sodium, and potassium. Bromine has been detected by Glover and Heller, and chlorine by Orfila.

Iodide of potassium, the alkaline borates, silicates, chlorates, and carbonates, as also chloride of barium, ferridcyanide of potassium, and sulphocyanide of potassium, were found by Wöhler[1] in the urine; the ferridcyanide was, however, converted into ferrocyanide in the system.

[1] Tiedemann's Zeitschr. für Physiol. vol. 1, p. 305.

Sulphur has been found (after administration) in the urine by Wöhler and Orfila; and after the use of liver of sulphur, free sulphur, and an excess of sulphate of potash were found in the urine. In four experiments made by Laveran and Millon, sulphur neither appeared in the urine, nor was the quantity of sulphates increased.

Metallic substances. Arsenic and antimony may be readily detected in the urine, and have been observed by many chemists. The detection of mercury is by no means easy; it has been sought for in vain by Lehmann, L'Heretier, and Rees, but has been found by Buchner, Cantu, Jourda, Venables, Orfila, Œsterlen,[1] and Audouard.[2] Iron is almost always present in the urine during its administration as a remedy. Nickel was found by Wöhler in the urine of a dog to whom he had given half a drachm of tartrate of nickel and potash. Gold, silver, tin, lead, and bismuth, were found in the urine of dogs to whom Orfila had given large doses of the soluble salts of those metals. Copper and manganese have been detected in the urine by Kramer.[3]

Inorganic acids. Orfila has detected nitric, hydrochloric, and sulphuric acids in the urine. As nitric acid is not a constituent of normal urine, there was no ambiguity in this experiment. In dogs poisoned with dilute hydrochloric or sulphuric acid, about six times as much chloride of silver and sulphate of baryta were obtained as are found in ordinary urine. In none of these cases was the urine more acid than usual, the acids having formed neutral salts by combining with the alkalies of the blood.

Organic acids and their salts. It appears from the investigations of Wöhler, that many of the organic acids, administered in a free state, enter the urine in a state of combination; as, for instance, oxalic, citric, malic, tartaric, succinic, and gallic acids.

To the above list Orfila has added acetic acid, and confirmed Wöhler's statement regarding oxalic acid.

According to Pereira[4] meconic acid may be occasionally detected in the urine of animals poisoned with opium.

[1] L'Expérience, Aug. 1844. [2] Journal de Chim. Méd. 9, p. 137.

[3] Giornale dell' Instituto Lombardo.

[4] Elements of Materia Medica, 1st ed. vol. 2, p. 1299.

One of the most important of Wöhler's discoveries is, that the neutral vegetable salts become modified in their passage through the system, and are found in the urine as carbonates. A few hours after the use of these salts, the urine becomes alkaline, is frequently turbid from the deposition of phosphates, and effervesces briskly on the addition of an acid.[1] If the dose is very large, oxalate of lime may frequently be detected. Similar results follow from the use of alkaline lactates; Lehmann found, that two hours after taking two drachms of lactate of soda, alkaline urine was excreted. That this change is effected after the salt has entered the blood, and not in the intestinal canal, is proved by an experiment performed by Mr. J. Goodsir, at my request. A drachm of acetate of potash was dissolved in an ounce and a half of water, and injected into the femoral vein of a dog, whose urine had been previously ascertained to be acid. The urine passed about an hour after the operation was alkaline. A similar experiment has been since made by Lehmann, who injected a drachm of lactate of potash into the jugular vein of a dog, and found the urine alkaline an hour afterwards. The process is one of simple combustion: each atom of acetic acid (of the acetate of soda) combines with eight of oxygen, and yields four atoms of carbonic acid and three of water, or $C_4 H_3 O_3 + 8O = 4CO_2 + 3HO$, and each atom of lactic acid combines of twelve of oxygen, forming six of carbonic acid and four of water, or $C_6 H_5 O_5 + 12O = 6CO_2 + 5HO$.

In a series of 268 experiments instituted by Millon and Laveran, with the tartrate of potash and soda, (Sodæ potassio-tartras. Ph. L.) they found the urine more or less alkaline in 175, acid in 87, and neutral in 6 cases. This apparent discrepancy was doubtless dependent on the degree of concentration of the saline solution. (See page 149.)

We have already mentioned that benzoic and cinnamic acids are converted in the organism into hippuric acid, and then excreted by the kidneys.

Vegetable bases. Quinine, when administered in large doses, has been noticed in the urine by Piorry, Landerer, and others.

[1] Some excellent observations on the physiological action of these salts will be found in Dr. Pereira's Treatise on Food and Diet, p. 29.

The best test for its presence is the iodated iodide of potassium, consisting of four parts of iodide of potassium, one of iodine, and ten of water. The precipitate afforded by this reagent with disulphate of quinine is very insoluble in water, not affected by an excess of the test, and readily soluble in alcohol. It is of a yellowish-brown colour, and forms a turbidity or sediment, according to the amount of the alkaloid in the urine. When the quantity is very small there is merely an olive tint produced on the addition of the test. The disulphate of quinine may be reobtained from the sediment in a state of purity by a simple chemical process.[1]

Morphia is stated to have been once detected by Barruel in the urine of a person under the influence of a poisonous dose of laudanum, and it was likewise discovered by Orfila, in the urine of dogs. None of the other alkaloids have yet been detected in the urine.

Indifferent organic substances. According to Wöhler, most colouring matters and many odorous principles passed unchanged or slightly modified into the urine. In the former class we may place indigo, gamboge, rhubarb, red beet-root, madder, logwood, mulberries, black cherries, &c.; in the latter, valerian, asafœtida, garlic, castoreum, saffron, turpentine, &c.

Alcohol is placed by Wöhler amongst the substances that do not enter the urine, and Liebig has recently affirmed that it has never been found in that secretion. It has, however, been detected by Percy in the urine of a dog, into whose stomach four ounces of spirit of ·85 had been injected, and in the urine of a man in a state of intoxication who had taken about a bottle of whiskey. In both cases he obtained, by careful distillation, an inflammable fluid that dissolved camphor.[2]

In order to ascertain whether alcohol, taken in moderate quantity would enter the urine, my friend Dr. Wright instituted the following experiment on a man whose ureters opened externally. Three ounces of whiskey were administered, and the urine collected by applying a test-tube to each ureter. The tubes were corked and replaced every two minutes, for the space of half an hour.

[1] Journal de Pharmacie, Sept. 1843.

[2] On the presence of Alcohol in the Brain, 1839, p. 104.

The following table represents the amount of fluid in the tubes.

1st two minutes	. .	½ a drachm.
2d ,,	. .	2 drachms.
3d* ,,	. .	5 drachms.
4th ,,	. .	1 drachm.
5th* ,,	. .	6 drachms.
6th* ,,	. .	2 drachms.
7th ,,	. .	½ a drachm.
8th ,,	. .	½ a drachm.
9th ,,	. .	3 drachms.
10th* ,,	. .	6 drachms.
11th ,,	. .	4 drachms.
12th ,,	. .	8 drachms.
13th* ,,	. .	7 drachms.
14th* ,,	. .	6 drachms.
15th* ,,	. .	4 drachms.

The contents of the tubes were analysed separately, according to Dr. Percy's method,[1] and in those marked with an asterisk the presence of spirit was distinctly recognized.

In another experiment upon the same individual, in which two ounces of whiskey diluted with three times its volume of water were administered, no trace of the spirit could be obtained.[2]

Lehmann has sought in vain for salicin, phloridzin, caffein, theobromin, asparagin, and amygdalin.

As the modifications that these substances undergo in the organism are of extreme interest, let us see what are the most probable changes that can take place. We select salicin, by way of illustration, as a substance whose chemistry is pretty well established.

Is salicin converted in the organism into sugar and saliretin ?[3] —a change that occurs on digesting salicin in dilute acids: or is it converted into salicylous acid and water?[4]—as occurs on treating salicin with bichromate of potash and sulphuric acid. Or, instead of salicylous acid, is hydrated benzoic acid (which is

[1] Op. cit. p. 8.

[2] These experiments were originally recorded in my Harveian Prize Essay on the Chemistry of the Urine in Health and Disease; 1842.

[3] This change is illustrated by the equation—

$$\underset{\text{Salicin.}}{C_{42}H_{29}O_{22}} = \underset{\text{Sugar.}}{C_{12}H_{14}O_{14}} + \underset{\text{Saliretin.}}{C_{30}H_{15}O_{8}}.$$

Symbolically—$\underset{\text{Salicin.}}{C_{42}H_{29}O_{22}} + \underset{\text{Oxygen.}}{O} = \underset{\text{Salicylous acid.}}{3C_{14}H_{6}O_{4}} + \underset{\text{Water.}}{11HO}.$

isomeric with it) produced,[1] and the benzoic acid then converted in the ordinary manner into hippuric acid? Or does the salicin yield salicylous acid which appears to be isomorphous with, and convertible into oxide of omichmyle?[2] Or, finally, does the salicin undergo the same changes as when oxidized by fusion with caustic potash, and become converted into salicylic, oxalic, and carbonic acids, and water?[3] In sixteen experiments made by Lehmann with salicin in doses of 20 or 30 grains, he never detected saliretin, but always salicylous acid, which was taken up by ether with the oxide of omichmyle, and yielded the characteristic violet tint on the addition of nitrate of iron; in most of the experiments there was also a small quantity of hippuric acid, and of oxalate of lime. Similar experiments have been made by Laveran and Millon.

After taking phloridzin, Lehmann also found hippuric acid and oxalate of lime in the urine. After taking a scruple of thein at bedtime, no trace of it could be found in the morning urine, but the urea was considerably increased, amounting to 58·195% of the solid residue.[4] He did not remark any unpleasant symptoms, but two of his pupils, after a similar dose (obtained from coffee) experienced great excitement of the nervous and vascular systems generally, and especially of the generative organs. This is perfectly in unison with Mulder's[5] statement, that it produced abortion in pregnant rabbits.]

1 Symbolically—$\underset{\text{Salicylous acid.}}{C_{14}\,H_6\,O_4} = \underset{\text{Hydrated benzoic acid.}}{HO,\,C_{14}\,H_5\,O_3}$.

2 It appears from the researches of Scharling that the oxide of omichmyle belongs to a series having a compound radical analogous to that of oil of spiræa, or salicylous acid; at least he found that chloromichmyle is isomeric with chloride of salicyl or chlorosalicylic acid, $C_{14}\,H_5\,O_4$, Cl. Oxide of omichmyle does not produce a violet colour with nitrate of iron in the same manner as salicylous and salicylic acids; moreover, salicylous acid and salicin do not enter the urine as oxide of omichmyle, but as salicylous acid, as has been found by Lehmann in eight experiments. Scharling hints at the existence of a widely-diffused radical, which, in the vegetable kingdom, in warm climates, is the starting point of the benzoyl and cinnamyl series; in cold climates, of the salicyl compounds; and, in the animal kingdom, presents itself as omichmyle.

3 These changes may be thus explained symbolically:

$$\underset{\text{Salicin.}}{C_{42}\,H_{29}\,O_{22}} + \underset{\text{Oxygen.}}{29O} = \underset{\text{Salicylic acid.}}{2C_{14}\,H_6\,O_6} + \underset{\text{Oxalic acid.}}{6C_2\,O_3} + \underset{\text{Carbonic acid.}}{2CO_2} + \underset{\text{Water.}}{17HO.}$$

4 Lehrbuch der Physiolog. Chemie, vol. 1, p. 97.

5 Natuur en Scheikundig Archief, 1839, p. 458.

Urine of Animals.

The chemistry of the urine of animals is still in a very deficient state. I shall here give the little that is known on the subject.

The urine of carnivorous animals is, at the period of its discharge, acid, but speedily becomes alkaline, in consequence of the formation of ammonia. This observation of Hieronymi's is confirmed by Hünefeld, who found that the urine of the bear retained its acid reaction for a considerable period. Vauquelin found a large proportion of urea, but no uric acid in the urine of beasts of prey. Hünefeld also missed the uric acid, but it was detected by Hieronymi. Hieronymi carefully analysed the urine of the lion, the tiger, and the leopard, and its composition appeared much the same in these three animals. The specific gravity of the urine of each animal varied between 1059 and 1076. It was clear, of a bright yellow colour, had a pungent disagreeable odour, an acid reaction, and a nauseous bitter taste; after standing for a short time, it became alkaline. On collecting and evaporating the urine, there was a coagulation of some white flocculent matter; and as the concentration increased, the greater part of the urea began to separate in a crystalline form. The mixed urine of these three animals gave the following result:

Water	846·00
Solid constituents	154·00
Urea, alcohol-extract, and free lactic acid	132·20
Uric acid	0·22
Vesical mucus	5·10
Sulphate of potash	1·22
Chloride of ammonium, and a little chloride of sodium	1·16
Earthy phosphates	1·76
Phosphates of soda and potash	8·02
Phosphate of ammonia	1·02
Lactate of potash	3·30

The urine of herbivorous animals likewise contains a large quantity of urea, but no uric acid,[1] there being in its place hippuric acid. The urine of the horse was analysed by Fourcroy and Vauquelin: they describe it as of a yellow colour, often

[1] [Traces of uric acid have been occasionally detected by Fownes and other chemists' in the urine of the graminivora. See Vol. I, p. 53.]

turbid, of an unpleasant smell, and a saltish bitter taste. When allowed to rest, a quantity of the carbonates of lime and magnesia was deposited; it had an alkaline reaction, frothed on the addition of an acid, and had a specific gravity of from 1030 to 1050. 1000 parts contained:

Water	940·0
Solid constituents	60·0
Urea	7·0
Hippurate of soda	24·0(?!)
Chloride of potassium	9·0
Carbonate of soda	9·0
Carbonate of lime	11·0

This analysis probably requires further confirmation. I found a larger amount of urea in the urine of a horse suffering from ozæna; for from 1000 parts I obtained 50 of urea; and after the horse had fasted for four days, I still found 24·1. In the urine of another horse, the solid constituents amounted to 10·7% of the urine, and the urea to 5·06%, or about one half of the solid residue.

From my own observations, I should say that the urine of horses is generally of a straw colour, is at first acid, but soon becomes ammoniacal, and then emits the peculiar penetrating odour which is doubtless caused by the formation of a volatile fatty acid, although I was unable to isolate it. The urine, after it has become alkaline, is often so tenacious and viscid that it can be drawn up in long threads. The microscopic examination of the urine of the horse exhibits a great number of rounded corpuscles, from the size of mucus-corpuscles to four times that size, which burst upon pressure of the glass slips between which the fluid is examined. Fourcroy and Vauquelin, after evaporating the urine of the horse, separating the urea as a nitrate, and neutralizing the acid by an alkali, found a small quantity of reddish fat, which volatilises over the water-bath, and is considered to be the cause of the smell and colour of the urine.

[The urine of the horse has been recently analysed by Von Bibra[1] and Boussingault.

In two analyses of the urine of the same horse, made at different periods, Von Bibra found:

[1] Annalen der Chemie und Pharmacie, 1845, No. 1.

	1.	2.
Water	885·09	912·84
Solid constituents	114·91	87·16
Urea	12·44	8·36
Hippuric acid	12·60	1·23
Water-extract	21·32	19·25
Alcohol-extract	25·50	18·26
Mucus	0·05	0·06
Salts soluble in water	23·40	40·00
Salts insoluble in water	18·80	

On two occasions the individual salts were determined, and it was found that in 100 parts of the saline residue there were:

	1.	2.
Carbonate of lime	12·50	31·00
Carbonate of magnesia	9·46	13·07
Carbonate of potash	46·09	40·33
Carbonate of soda	10·33	
Sulphate of potash	13·04	9·02
Chloride of sodium	6·94	5·60
Silica	0·55	0·98
Loss	1·09	

Traces of iron were always observed, but he could never ascertain the presence of fluorine. The mean specific gravity resulting from numerous observations was 1045. The horses, in these cases, were used for agricultural purposes, and fed on hay and oats. The prevailing opinion that, by excessive work, the hippuric is replaced by benzoic acid, is stated by Von Bibra to be incorrect. Benzoic acid was scarcely ever observed, and, when present, was only recognizable under the microscope. The hippuric acid varied in different analyses from 15 to 5 or even less in 1000 parts of urine. The secretion was always alkaline, and in a few minutes deposited a sediment, consisting (as seen under the microscope) of compact vesicles. The deposit consisted of the carbonates of lime and magnesia, with an organic compound that could not be removed by the most careful washing. In three analyses there were found:

Carbonate of lime	80·9	87·2	87·5
Carbonate of magnesia	12·1	7·5	8·2
Organic matter	7·0	5·3	4·3
	100·0	100·0	100·0

Boussingault[1] has likewise analysed the urine of a horse feeding on trefoil and vetches. It was very alkaline, had a specific gravity of 1037·3, and contained in 1000 parts:

[1] Annal. de Chimie et de Physique, Septembre, 1845.

Water and indeterminate matters	910·76
Urea	31·00
Hippurate of potash	4·74
Lactate of potash	11·28
Lactate of soda	8·81
Bicarbonate of potash	15·50
Carbonate of lime	10·82
Carbonate of magnesia	4·16
Sulphate of potash	1·18
Chloride of sodium	0·74
Silica	1·01
Phosphates	absent.

As several chemists have noticed, amongst the constituents of the urine of the herbivora, a red oil on which the colour and odour of the secretion are dependent, Boussingault endeavoured to isolate it. He distilled upwards of 26 gallons at a single experiment, but did not obtain a trace of the oil, a colourless fluid passing over which evolved the peculiar odour of horses' urine: hence he concluded that the odorous principle is a volatile acid. The only means by which anything like a red oil can be obtained consists in carrying on the distillation to dryness, in which case an oily substance is obtained, analogous to, if not identical with some of the products of decomposition of the alkaline hippurates.]

Horses are not unfrequently subject to a disease which corresponds with diabetes insipidus, or hyperdiuresis, in man: it has also been observed in sheep and cattle.

The following analysis of the urine of cattle was made by Sprengel: 1000 parts contained:

Water	926·24
Solid constituents	73·76
Urea	40·00
Albumen	0·10
Mucus	1·90
Benzoic acid	0·90
Lactic acid	5·16
Carbonic acid	2·50
Potash	6·64
Soda	5·54
Silica	0·36
Alumina	0·04
Oxide of manganese	0·01
Lime	0·65
Magnesia	0·36
Chlorine	2·72
Sulphuric acid	4·05
Phosphorus	0·70

This analysis requires further confirmation.

The urine of cattle, just after it is passed, is clear and acid; it soon, however, deposits crystals of the carbonates of lime and magnesia. It contains hippurate of soda, and a larger proportion of urea than is found in human urine.

[The urine of oxen employed for agricultural purposes was analysed by Von Bibra. The specific gravity varied from 1040 to 1032. The urine was of a dark yellow colour, perfectly clear, and of a peculiar odour.

The following analyses were made with the urine of the same animal at different times:

	1.	2.
Water	912·01	923·11
Solid constituents	87·99	76·89
Urea	19·76	10·21
Hippuric acid	5·55	12·00
Mucus	0·07	0·06
Alcohol-extract	14·21	10·20
Water-extract	22·48	16·43
Soluble salts	24·42	25·77
Insoluble salts	1·50	2·22

The saline residue contained:

Carbonate of lime	1·07
Carbonate of magnesia	6·93
Carbonate of potash	77·28
Sulphate of potash	13·30
Chloride of sodium	0·30
Silica	0·35
Traces of iron, and loss	0·77
	100·00

Although these salts are liable to considerable quantitative variations, (for instance, Von Bibra, in two analyses, found 14·22 and 16% of chloride of sodium,) yet, as a general rule, the urine of oxen contains more alkaline and less earthy carbonates than the urine of horses.

The urea and hippuric acid varied extremely in different analyses. The food of the oxen consisted of fresh clover and a little hay.

Boussingault found that the urine of a cow feeding on aftermath and potatoes, effervesced briskly on the addition of an acid, and deposited numerous crystals of hippuric acid. Its specific gravity was 1040, and it contained in 1000 parts:

Water and indeterminate matters	921·32
Urea	18·48
Hippurate of potash	16·51
Lactate of potash	17·16
Bicarbonate of potash	16·12
Carbonate of magnesia	4·74
Carbonate of lime	0·55
Sulphate of potash	3·60
Chloride of sodium	1·52
Silica	traces
Phosphoric acid	absent]

Vogel found the urine of the rhinoceros turbid, and having an odour like that of crushed ants. It grew darker after exposure to the air, and became covered with a film of carbonate of lime; it effervesced on the addition of acids. As it cleared, it deposited a yellow sediment composed of earthy phosphates with a little peroxide of iron and silica, which amounted to 2·7% of the weight of the urine. It then remained of a dark yellow colour, and formed, on evaporation, a new sediment of carbonates of lime and magnesia, which were previously held in solution as bicarbonates. On evaporating the urine to two thirds of its volume, and then treating it with hydrochloric acid, a precipitation of hippuric acid took place, amounting to 0·45% of the weight of the urine. The urine also contained urea and the ordinary salts.

Vogel found the urine of the elephant turbid from the presence of carbonates of lime and magnesia in suspension; it contained a larger amount of urea than the urine of the rhinoceros, but, on the other hand, was devoid of hippuric acid. Brandes, however, detected the latter constituent, partly combined with an alkali and partly with urea.

In the urine of the camel, Chevreul found a large quantity of urea, but no uric acid; it contained, however, chloride of sodium, hippurate of soda, carbonate of soda, sulphate of potash together with a little sulphate of soda, carbonate of ammonia, and a trace of peroxide of iron: no phosphates were found in it. On mixing it with sulphuric, nitric, or hydrochloric acid, the urine became red,—a property due to its containing a volatile oil, to which, moreover, it owes its odour.

The urine of the pig has been analysed by Lassaigne. He describes it as being of a pale yellow colour, clear and trans-

parent, and containing urea, sulphates of potash and soda, chlorides of potassium, sodium, and ammonium, and traces of carbonate and sulphate of lime. Van Setten[1] has communicated a special analysis of the urine of a pig. It was yellow, almost inodorous, and had a specific gravity of 1003.

There were contained in 1000 parts:

Water	990·028
Solid constituents	9·972
Urea	0·750
Uric acid	0·195
Water-extract	1·708
Alcohol-extract	1·105
Resinous matter	0·425
Albumen and mucus	0·721
Lactic acid	0·490
Stearin	0·092
Sugar	0·375
Phosphate of soda	1·376
Sulphate of potash, chlorides of sodium & potassium	2·075
Sulphates of lime and magnesia	0·425
Sulphate of ammonia	0·196
Chloride of ammonium	0·010

[The urine taken from the bladders of pigs immediately after they were killed is described by Von Bibra as clear, nearly devoid of odour, alkaline, and having a specific gravity of 1012 to 1010. In two cases in which he analysed it he found in 1000 parts:

	1.	2.
Water	981·96	982·57
Solid constituents	18·04	17·43
Urea	2·73	2·97
Alcohol-extract	3·87	3·99
Water-extract	1·42	1·12
Mucus	0·05	0·07
Soluble salts	9·09	8·04
Insoluble salts	0·88	0·80

The salts in the first of these analyses consisted of:

Chloride of sodium and a little chloride of potassium	53·1
Sulphate of soda	7·0
Carbonate of potash	12·1
Phosphate of soda	19·0
Phosphates of lime and magnesia, with traces of silica and iron	8·8
	100·0

[1] Natuur en Scheidekundig Archiv, Deel 2.

In both the above analyses he searched in vain for hippuric or benzoic acid in three ounces of the fluid.

In two other analyses he obtained microscopic crystals of hippuric acid on the evaporation of the ethereal solution. He never detected even a trace of uric acid, which, considering the mixed nature of the food of these animals, is extraordinary.

Boussingault analysed the urine of a pig feeding on potatoes and water slightly impregnated with salt. The urine was alkaline, very limpid, and of an extremely pale yellow colour. Its specific gravity was 1013·6.

It contained in 1000 parts:

Water and indeterminate organic matter	979·14
Urea	4·90
Bicarbonate of potash	10·74
Carbonate of magnesia	0·87
Carbonate of lime	traces
Sulphate of potash	1·98
Phosphate of potash	1·02
Chloride of sodium	1·28
Alkaline lactates	undetermined
Hippuric acid[1]	absent
Silica	0·07

The urine of the goat has been analysed by Von Bibra. The animals from whom the fluid was obtained were confined in a stable and poorly fed, getting sour hay, &c. The urine was clear, of a peculiar but pungent odour, and alkaline. The specific gravity was generally 1008 or 1009. In two instances it contained in 1000 parts:

	1.	2.
Water	980·07	983·99
Solid residue	19·93	16·01
Urea	3·78	0·76
Hippuric acid	1·25	0·88
Alcohol-extract	4·54	4·66
Water-extract	1·00	0·56
Mucus	0·06	0·05
Soluble salts	8·50	8·70
Insoluble salts	0·80	0·40

[1] Thinking that the absence of hippuric acid might be dependent on the diet, Boussingault mixed green trefoil with the potatoes: the result was, however, still the same.

The ash consisted of:

Carbonate of magnesia with a little carbonate of lime	7·3
Sulphate of soda	25·0
Chloride of sodium . . .	14·7
Carbonate of soda with a little carbonate of potash	53·0
	100·0

Here we remark, as in the urine of oxen, a considerable excess of the alkaline carbonates over the alkaline earths. The hippuric acid seemed very variable, sometimes equalling the urea in amount.]

Vauquelin analysed the urine of the beaver. He found in it the bicarbonates of lime and magnesia, and hippurate of soda, but no phosphates or uric acid. He also detected the undecomposed colouring matter of the bark of the willow (the ordinary food of the beaver) in the urine; for he found that a piece of cloth which had been previously saturated with alum, took up the same colour from soaking in the urine as from lying in a decoction of the aforesaid bark.

The urine of rabbits and guinea-pigs is much the same: it has an alkaline reaction, froths on the addition of an acid, and, when exposed to the air, throws down a sediment of carbonate of lime: it contains urea and the salts which are generally met with in the urine of the herbivora.

[The urine of the hare has been examined on two occasions by Von Bibra. The first analysis was made in December. By external pressure on the region of the bladder he was enabled to collect about three pints from seven or eight hares. This was divided into two portions, one of which was evaporated and incinerated, the other tested for hippuric acid, which was found to be present in small quantity, forming 0·007% of the urine.

The ash contained:

Chloride of sodium with a little chloride of potassium	7·12
Sulphate of soda	16·82
Carbonate of soda . . .	9·84
Phosphate of soda . . .	53·05
Phosphates of lime and magnesia . .	13·17
	100·00

The urine was turbid and alkaline, depositing a white sediment of minute globules, much smaller than those occurring in the urine of the horse, and consisting, for the most part, of phosphate of magnesia. The urine similarly obtained in the month of June had a faint alkaline reaction, and, in the course of six hours, crystals of ammoniaco-magnesian phosphate were observed on the surface. Its specific gravity was 1050, and it contained in 1000 parts:

Water	912·86
Solid constituents	87·14
Urea	8·54
Hippuric acid	microscopic crystals
Alcohol-extract	9·58
Water-extract	32·68
Soluble salts	23·70
Insoluble salts	12·64

The ash consisted of:

Chloride of sodium with a little chloride of potassium	22·49
Sulphate of soda	29·97
Carbonate of soda	8·73
Phosphate of soda	4·39
Phosphate of lime	12·00
Phosphate of magnesia	22·42
	100·00

The difference in the amount of earthy phosphates in these analyses is easily accounted for when we consider the different nature of the food in winter and summer.

Von Bibra obtained a minute quantity of a substance closely allied to humic acid in most of his analyses of the urine of the herbivora.]

The urine of birds, which is discharged from the cloaca as a white pulpy mass and soon hardens when exposed to the air, is remarkable for the large quantity of urate of ammonia which it contains. The urine of birds of prey contains urea, and a peculiar green colouring matter which is not found in the urine of graminivorous birds.

Vauquelin and Fourcroy found that, in the ostrich, the uric acid amounted to one sixtieth of the weight of the urine; there were also present sulphates of potash and lime, chloride of ammonium, an oily substance, a peculiar animal matter, and probably acetic acid. The urine of the parrot is, according to J. Davy, very similar to that of serpents.

The urine of serpents is excreted as a white, pultaceous, earthy mass, which soon stiffens when exposed to the air. It is composed, for the most part, of uric acid in combination with potash, soda, and ammonia, together with a little phosphate of lime. It contains no urea, since, upon digesting it in alcohol, a yellow extractive matter is taken up, in which no crystals of urea can be detected.

On the other hand, Berzelius directs our attention to the circumstance that Cap and Henry have obtained urea from that source, after having saturated the uric acid with hydrated baryta.

[For an analysis of the urine of the rattle-snake, see Vol. I, p. 53, note.]

The urine of the bull-frog (*rana taurina*) consists, according to J. Davy, of a fluid of specific gravity of 1003, which contains urea, chloride of sodium, and a little phosphate of lime in solution. The urine of *bufo fuscus* had a specific gravity of 1008; it contained a larger proportion of urea than the urine of the frog, together with chloride of sodium and phosphate of lime. In the urine of *testudo nigra*, which was examined by Magnus and J. Müller, there was no uric acid; on the other hand, there was 0·1% of urea, with a brown colouring matter which was soluble in water, spirit, potash, and hydrochloric acid.

[The urine of a land-tortoise (*testudo tubulata*), which had been kept without food for some months, has been recently examined by Marchand.[1] It had a faintly acid reaction, and resembled pus in appearance. He collected 1337 grains, consisting of:

		Or in 1000 parts:
Water	1271	950·64
Solid constituents	66	49·36
Urea	8·5	6·40
Uric acid	23·0	17·25
Hippuric acid	none	
Salts and indeterminate organic matter	34·5	25·70]

A small quantity of brown liquid fat, with a strong urinous odour, was taken up by ether.]

[1] Erdmann und Marchand's Journ. 1845, iv, 4.

CHAPTER VIII.

THE SECRETIONS OF THE LACHRYMAL, MEIBOMIAN, AND CERUMINOUS GLANDS.

The Tears.

THE glandulæ lachrymales are two conglomerate acinous glands which secrete a limpid fluid, containing a very small proportion of solid constituents, and forming the tears. They are for the purpose of preserving the cornea of the eye in a state of moisture, and their secretion is much increased by intense feelings either of joy or grief.

The tears have not yet been subjected to an accurate analysis, partly perhaps from the subject being one of little interest in a scientific point, and partly from the difficulty of obtaining a sufficient quantity.

When examined under the microscope, the tears exhibit a small quantity of pavement epithelium and a few mucus-corpuscles swimming in a clear fluid. They have a slightly saline taste, (much like that of the perspiration that exudes from the forehead,) and change red litmus-paper to a pale blue.

The only chemical examination of the tears that can be depended on is that of Fourcroy and Vauquelin, who assert that they resemble in their constitution the aqueous humour of the eye. The solid constituents amount to only 1%, and consist principally of chloride of sodium and of a yellow extractive matter which is not perfectly soluble in water: it is not improbable that the insoluble portion arises from the fatty-mucous secretion of the meibomian glands. The mucus also into which, according to those chemists, the extractive matter of the tears is converted previously to its being perfectly dried, may be, as Berzelius conjectures, the secretion of the meibomian glands. With regard to this latter secretion,—the gummy secretion of the eyes, we know even less than of the tears: it seems to consist principally of a mucous matter and of fat.

Cerumen.

The glandulæ ceruminosæ, which are situated in the external skin of the meatus auditorius externus, secrete the ear-wax (cerumen), a peculiar salve-like matter, which is thrown out as a yellowish milk.

If a small portion of ear-wax is pressed between two slips of glass and observed under the microscope, we shall find a quantity of variously-grouped lamellæ lying in a tolerably homogeneous yellow mass. In these lamellæ, the practised observer will easily recognize pavement epithelium. On mixing the ear-wax with water, which may be readily done, a sort of yellowish milk is obtained, in which, with the microscope, we may observe colourless fat-vesicles, epithelium-scales, and sometimes rhombic crystals, very like cholesterin. The yellow colour of the cerumen does not belong to the fat, but to the matter which is soluble in water. Berzelius has made the following observations on the cerumen. Ether takes up fat from the mass which swells in it, and becomes as soft as goose-grease; it has not an acid reaction, consists of stearin and olein, and contains a substance which, after saponification, gives off a strong smell of sweat. The fatty acids which are liberated on the addition of hydrochloric acid melt at 104°. After the fat has been removed, alcohol takes up a yellow substance from the ear-wax, which, on evaporation of the alcohol, is left as a glossy matter, perfectly soluble in water, and of a very bitter taste. It may be entirely thrown down from its aqueous solution by the neutral acetate of lead and by chloride of tin; on the other hand, nitrate of silver does not even render it turbid; hence there can be no chlorides present. Upon incinerating this mass, there remains an ash, which consists of the carbonates of potash and lime. The portion not dissolved by alcohol yields to water a small amount of yellowish matter, which is very similar to the soluble matter obtained in a similar manner from the other fluids of the animal body, and has a piquant taste; but it is distinguished by the circumstance that neither lime-water, basic acetate of lead, bichloride of mercury, nor tannic acid precipitate it.

The portion of the ear-wax which is insoluble in ether,

alcohol, and water, is, next to the fat, the largest: acetic acid causes it to swell, and only takes up a very small portion of an albuminous matter. The residue (consisting evidently of nothing but epithelium-cells) is partly soluble in free potash, from which it cannot be again precipitated by acetic acid; ferrocyanide of potassium causes no precipitate in the acid solution, but infusion of galls a very copious one. Another portion of the residue, when heated with a concentrated solution of potash, enters into combinations which are not soluble in that fluid, but which are soluble in water, similar to what is observed in the urine.

This investigation shows that the ear-wax is an emulsive compound, which contains a soft fat, albumen, a peculiar extractive bitter matter, epithelium-scales, lactate of lime, and an alkaline lactate, but no chlorides and no phosphates soluble in water.

CHAPTER IX.

SECRETIONS AND FLUIDS OF THE GENERATIVE ORGANS.

1. *Secretions of the male generative organs.*

SEMEN.

The seminal fluid which is formed in the testicles and is conveyed along the vas deferens, is a thick, whitish, glutinous mass possessing a peculiar odour, and when examined under the microscope is found to be composed of a clear fluid, in which an immense number of minute caudate molecules, the spermatozoa, appear to be moving about at will. (Fig. 33.) In addition to the spermatozoa, seminal granules are likewise to be seen, which, according to Wagner, are rounded, fine granular corpuscles of $\frac{1}{310}$ — $\frac{1}{400}$ of a line in diameter, and a few epithelium-scales.

The spermatozoa occur in the semen of nearly all animals: they are elliptic in man, but assume various forms in different classes of animals.

The chemical analysis of the semen, although not an uninteresting subject, seems little calculated to throw any light upon the remarkable process that is recognized in the term impregnation. We cannot even form any conjecture regarding the connexion and the reciprocal effect that must take place between the fructifying semen and the ovum which is to be fructified; and although we cannot doubt that there are certain chemical processes going on, since the act of impregnation is succeeded by a change not only of form but of matter, we have as yet but little prospect of investigating the subject successfully, in consequence of the insufficiency of our resources.

The seminal fluid at the period of emission is somewhat turbid, and is mixed with the mucous secretion of the prostate, from which it cannot be separated. It has not always the same

consistence, and the longer it remains in the vesiculæ seminales, the more consistent it becomes.

The investigations of Vauquelin, Jordan, and John have elicited the following results, which, however, do not sufficiently explain its chemical relations. When the seminal fluid has been allowed to rest for some time, it becomes clear, more fluid, transparent, and almost entirely soluble in water; if, on the contrary, it is at once dropped into water it sinks, and instead of perfectly dissolving, it coagulates in threads, in the same manner as if it had been treated with alcohol. This coagulated matter is readily soluble in acetic acid, and the solution gives a copious precipitate on the addition of ferrocyanide of potassium.

On allowing the coagulum to remain in water, it gradually dissolves therein, leaving a residue of a few flocculi. The solution, if rapidly evaporated, gives off the peculiar odour of semen, and leaves a clear glossy residue, which is opaque in water, and only partially dissolves in that fluid. From the portion which is insoluble in water, alcohol takes up extractive matter; and the portion insoluble in alcohol dissolves in boiling water, leaving a mucous residue: the solution is precipitable by acetate of lead, chloride of tin, bichloride of mercury, nitrate of silver, and infusion of galls.

In semen which had stood for some time, Vauquelin found four-sided prisms arranged in stellar groups, and terminating in long four-sided pyramids, which Berzelius considers to have been ammoniaco-magnesian phosphate. If the semen is allowed to evaporate it becomes covered with a film, in which white points may be observed, which are supposed by Vauquelin to be composed, as well as the before-mentioned prisms, of phosphate of lime. When the whole of the water has been removed by evaporation, there remains a yellow, transparent, elastic mass, which amounts to 10% of the weight of the semen.

Vauquelin, moreover, states that fresh semen is soluble in all acids, from which it cannot be precipitated by alkalies, and conversely, that it is soluble in the alkalies, from which it is not precipitable by acids: chlorine-water, however, coagulates it to such a degree as to render it insoluble in water or acids. If the semen at the moment of emission is allowed to fall into alcohol, and to remain in it for some time, it coagulates tho-

roughly, becomes opalescent, and resembles a long thread: it is now incapacitated from returning to a state of solution like fresh semen, but remains, on being dried, fibrous, snow-white, and opaque. It gradually softens in water, but even at the boiling point only a very small portion dissolves in that fluid; it swells, however, like mucus. If the water in which it has been boiled is evaporated, a white matter remains, which is partly soluble in cold, partly in boiling water, and the solution is freely precipitable by tannic acid. That portion of the semen, after coagulation by alcohol, which is not soluble in boiling water, will also resist the action of dilute solution of potash at a moderate temperature; it will, however, dissolve on being heated with a concentrated solution of caustic potash, and it cannot be again precipitated from this solution by acetic acid. With concentrated sulphuric acid it forms a yellow fluid, without the application of heat; on the addition of water it is precipitated with a white colour, and the precipitate is not soluble in an excess of water.

With acetic acid the coagulum becomes gelatinous and transparent; on being diluted and warmed it dissolves, but does not form a perfectly clear fluid: this is only rendered turbid by ferrocyanide of potassium, is not precipitated by bichloride of mercury or carbonate of ammonia, but by tannic acid is thrown down in light floccules, which continue for a long time in suspension.

From these researches Berzelius concludes that the semen contains a peculiar matter which may be obtained in two separate states depending upon whether it be projected into water or alcohol. When coagulated by alcohol it has an external resemblance to fibrin, and, moreover, like that substance, it can be precipitated from its acetic-acid solution by ferrocyanide of potassium: on the other hand, it differs from it in its solubility in nitric acid, and in its power of resisting the soluble action of a cold solution of potash.

On heating the residue of the semen it becomes yellow, emits an odour of burnt horn, gives off a considerable quantity of ammonia, and leaves a carbonacious mass which is not easy of incineration, and contains carbonate of soda, chloride of sodium, and phosphates of lime and magnesia. Vauquelin assigns the following composition to the seminal fluid.

In 100 parts there are—

Peculiar extractive matter	6
Phosphate of lime	3
Soda	1
Water	90

According to John, the seminal fluid contains a substance resembling mucus, with small quantities of a peculiar form of albumen, of a substance slightly soluble in ether, of soda, phosphate of lime, chloride of sodium, sulphur, and a volatile odorous principle.

The *prostatic fluid* which mixes with the semen of the male, at the moment of emission, has never yet been procured in sufficient quantity for analysis: it forms an almost clear fluid, which may be drawn out in threads.

2. *Secretions of the female generative organs.*

LIQUOR AMNII.

The liquor amnii surrounds the fœtus: at the period of delivery the membranes which contain it give way, and it escapes externally. Although it has been submitted to numerous analyses, its nature, even now, is not clearly understood. Human liquor amnii is turbid, and holds in suspension flocculi of caseous matter, arising from the vernix caseosa with which the fœtus is covered. Its specific gravity is 1005, and it contains from 1·2% to 1·6% of solid constituents; but according to Fromherz and Gugert, as much as 3%. It has a very decided alkaline reaction, but the indications of this reaction disappear when the test paper is dried; it is consequently dependent on free ammonia.

Alcohol took up extractive matter from the residue of the liquor amnii, and there remained, according to Fromherz and Gugert, a quantity of albumen, salivary matter (ptyalin), and casein.

When evaporated to the consistence of a syrup, and treated with hydrochloric acid, acid flocculi separated themselves, which were recognized, after a careful analysis, as benzoic acid. Berzelius, however, supposes that it might have been hippuric acid. After the fluid had been filtered, and the above matter removed, nitric acid was added and the mixture submitted

to the action of cold. Verrucose crystals then separated themselves, which were assumed to be composed of nitrate of urea, without being further analysed.

The salts of the liquor amnii are described as consisting of chloride of sodium in large quantity, phosphate, sulphate, and carbonate of soda, sulphate of lime, and a small amount of potash-salts.

The analyses of Voigt, which were made with the liquor amnii of women who had died in various stages of pregnancy, give discordant results, probably as Berzelius supposes from the circumstance of the fluid at the full time being different from what it was in the early stages of pregnancy. The liquor amnii at the fourth month was not turbid, had an insipid taste, a specific gravity of 1018·2, a neutral reaction, frothed upon being shaken, coagulated on boiling, was precipitated by bichloride of mercury and tannic acid, and less copiously by perchloride of iron and acetate of lead. After coagulation by boiling, the fluid which had been cleared by filtration, was strongly precipitable by nitric acid, while it was very little affected by chloride of barium, lime-water, ammonia, or oxalate of ammonia. Perchloride of iron, and chloride of platinum, produced no effect upon it.

The liquor amnii at the sixth month was turbid, yellowish, viscid, had a specific gravity of 1009·2; when heated to the boiling point gave a mucous coagulum which could not be separated by filtration, and its behaviour towards reagents was the same as in the former case. As to casein, ptyalin, urea, benzoic and hippuric acids, Voigt was as unable to find them as carbonate of ammonia or sulphuret of ammonium, and he conceives that at least some of these substances may arise from the fœtal urine which becomes mixed with the liquor amnii previous to delivery. Voigt's view of the composition of the liquor amnii is as follows:

	At the 4th month.	At the 6th month.
Water . . .	979·45	990·29
Alcohol-extract and lactate of soda	3·69	0·34
Albumen . . .	10·77	6·67
Chloride of sodium . .	5·95	2·40
Sulphate and phosphate of lime .	0·14	0·30

[Four specimens of liquor amnii examined by Dr. Rees[1], extracted from four individuals in the 7½ month of pregnancy, contained the same constituents. The specific gravity varied from 1008·6 to 1007. They were alkaline, contained urea, and the same salts as occur in the blood. One specimen contained:

Water			984·98
Solid constituents			15·02
Albumen with traces of fatty matter			1·80
Extract soluble in water	Salts	2·80	6·02
	Organic matter, chiefly albumen	3·22	
Do. soluble in water and alcohol	Salts	2·80	7·20
	Organic matter, chiefly lactic acid and urea	4·4	

The caseous matter floating in the liquid contained cholesterin.

The liquor amnii at the full time has been recently analysed by Mack,[2] who obtained two specimens for examination from Dr. Mikschik. The fluid in both cases was perfectly pure, the membranes being ruptured as they projected from the external organs.

The quantity of the fluid in the first case amounted to a little more than an ounce and a half; it was turbid, with white flocculi of vernix caseosa in suspension; it had a sickly odour, and a faintly saline taste. Under the microscope there were seen isolated mucus-corpuscles, with pavement and ciliated epithelium. The specific gravity was 1006·3, and the reaction faintly alkaline. The fluid coagulated slightly on heating, and became covered with a thin membrane during evaporation.

The amount of fluid obtained in the second instance was slightly above two ounces; the specific gravity was 1004·7; the reaction alkaline; and the other physical characters the same as in the former case. In 1000 parts there were contained:

	1.		2.	
Water	985·147		988·123	
Solid constituents	14·853		11·877	
Fat	1·250		0·132	
Alcohol-extract	5·251		4·752	
Water-extract	4·651		4·352	
Matter insoluble in water	3·701		2·641	
Sulphate of lime	1·722	9·333	1·672	9·236 fixed salts.
Chloride of sodium and carbonate of soda	7·611		7·564	

[1] Phil. Mag. (3d series) vol. 13, p. 395.

[2] Heller's Archiv für physiol. und pathol. Chemie und Mikroskopie, vol. 2, p. 218.

Urea and hippuric acid were carefully, but unsuccessfully, sought for in both specimens; neither could carbonate or hydrosulphate of ammonia be detected.

It is suggested by Mack that the discrepancies in the results obtained by other chemists may be owing to their having examined the fluid mixed with blood, mucus, or urine. Two years ago he analysed a specimen (under the superintendence of Dr. Ragsky) which contained much blood and mucus. The fluid was of a dirty yellow colour, and deposited a sediment. Under the microscope there were seen blood- and mucus-corpuscles, with epithelium-cells. The specific gravity was 1011·2.

In 1000 parts there were contained:

Water	984·131
Solid constituents	15·869
Fat	0·4984
Alcohol-extract	0·8529
Water-extract	4·0998
Substances insoluble in water	10·4177]

Several analyses have been made of the liquor amnii of animals. A very remarkable observation on this subject was made by Prout. The liquor amnii of a cow in an early stage of pregnancy was of a yellow colour, and opaque in consequence of holding a large quantity of glittering particles in suspension; its taste was like that of fresh whey, it smelt like fresh milk, and was neutral to test paper. Upon heating it to the boiling point it coagulated; coagulation was, however, prevented by the addition of acetic acid: with chloride of barium it gave a copious precipitate. The fluid which had been boiled gave, after filtration and evaporation, crystallizable sugar of milk, from which alcohol took up a yellow extractive matter with some lactates. Berzelius remarks that the presence of sugar of milk in the liquor amnii at an early period, is of the greatest physiological interest, since it doubtless contributes to the nutrition of the fœtus. Prout gives the following as the composition of 100 parts of this fluid:

Water	97·70
Albumen	0·26
Alcohol-extract and lactates	1·66
Water-extract, salts, and sugar of milk	0·38

In the liquor amnii of a mare which Voigt examined, he also

found no urea. It had a specific gravity of 1005·1, and left a solid residue of 1·45%, half of which was soluble in alcohol: the portion which was not soluble in it consisted of albumen, chloride of sodium, and sulphate of lime.

In the liquor amnii of a cow, which was viscid, very thick, of a yellow colour, and had a saltish taste and an alkaline reaction, Lassaigne found albumen, mucus, a yellow matter analogous to bile, chlorides of sodium and potassium, carbonate of soda, and phosphate of lime: no extractive matters are enumerated amongst the constituents. The flocculi which are suspended in the liquor amnii of the cow are said by this chemist to be composed of albumen with 0·27 of their weight of oxalate of lime.

I have already treated of vaginal mucus, menstrual blood, and the secretion of the mammary glands; it still remains for me to offer a few remarks on the fluid of the allantois. The allantois with its inclosed fluid is absent in the human embryo: it is found, however, in many animals. It is situated above the amnion, and it is between these two membranes that the urine of the fœtus collects, being conveyed there by the urachus from the urinary bladder, and constituting the fluid of the allantois.

It has several times been the object of chemical investigation; it is clear, of a brown-yellow colour, of a bitter and saltish taste, and reddens litmus paper. Its specific gravity, according to Dzondi, fluctuates between 1003 and 1029. On evaporation flocculi are precipitated, which consist of albumen and phosphate of lime. The residue left after evaporation is very slightly soluble in alcohol, which takes up a yellowish-brown acid extractive matter, and white nacreous crystals which retain their form upon mixing the residue obtained by evaporation with water, and constitute allantoin, which was first termed by Vauquelin, amniotic acid, and by Lassaigne, allantoic acid. The substances remaining in the watery solution, are chloride of sodium, alkaline lactates, a salt of ammonia, and extractive matters. From the portion insoluble in alcohol, water takes up sulphate and phosphate of soda, phosphates of lime and magnesia, and a brown extractive matter which is copiously precipitated by infusion of galls. Whether the fluid of the allantois

contains urea as well as allantoin is a point not yet ascertained.[1]

In speaking of the liquor amnii we mentioned that the floccules which are seen swimming in it are derived from the peculiar caseous matter, the *vernix caseosa*, which invests the fœtus. I shall avail myself of this opportunity of offering a few remarks upon this substance. Upon examining this caseous investment with the microscope, I found, especially when it had been previously diluted with water, a very large quantity of pavement epithelium, numerous fat-vesicles, and some but not a great many crystals, which in part resembled cholesterin, and in part distinctly assumed the form of ammoniaco-magnesian phosphate.

Upon examining the vernix caseosa by the microscope, without previously diluting it with water, indications of a large number of crystals presented themselves; they disappeared, however, on the addition of water, and I concluded that this peculiar appearance was caused by epithelium-cells.

According to Fromherz and Gugert the vernix caseosa consists of a mixture of fat resembling cholesterin with coagulated albumen. Microscopic investigation at once shows that what was considered by these observers as albumen, was at any rate for the most part epithelium, and that a considerable quantity of fluid fat must be present besides cholesterin. They also state that ether takes up from the vernix caseosa a fat which crystallizes in glittering leaves, which does not admit of saponification, and does not melt in boiling water. Cold water takes up a little of the portion which is insoluble in ether, and boiling water takes up a yellowish substance with an alkaline reaction, which they regarded as ptyalin, but which Berzelius conceives to be most likely albuminate of soda. The residue is evidently epithelium, since it is insoluble in a cold, but soluble in a boiling solution of potash.

[The most recent observations on the vernix caseosa are those of Dr. Davy.[2] He states "that its specific gravity (after the air that is entangled in it is removed) is 1003·9. It is very

[1] See vol. I, p 57. [2] Medico-chir. Trans. 1844, p. 193.

retentive of water. It required ten hours' exposure over the steam-bath, to expel from eight grains the whole of the water belonging to it, when it was reduced to 1·77 grain. A specimen of great purity taken from a healthy infant immediately after birth was found to consist of:

Water	77·87
Olein	5·75
Margarin	3·13
Epithelium-scales	13·25
	100·00

"A portion of the same was incinerated: it burned with a bright flame and left a very small quantity of white ash, hardly $\frac{1}{50}$th of a grain, although 40 grains was the quantity consumed, weighed before drying. This ash, in a drop of dilute muriatic acid, dissolved, emitting a distinct smell of sulphuretted hydrogen; and the solution was clouded by adding a little ammonia, indicating the presence of a minute portion of phosphate of lime and sulphur—the latter in union probably with lime or potash."]

CHAPTER X.

THE INTESTINAL EXCRETIONS.

THAT portion of the food which is not taken up by the absorbents which are everywhere distributed between the stomach and the large intestine is again discharged from the system as fæces.

The fæces must materially vary with the species of food that is taken, and with the energy of the digestive powers. When we see that many men are kept in a better and more desirable condition on a very small quantity of food, than others who take a larger amount of nutritious aliment, we must necessarily conclude that in the former case everything which could possibly serve for nutrition was extracted and suitably employed, while in the latter we must suppose that only a small portion of nutritive matter was taken up from the large quantity of food, and that the greater portion was discharged with the fæces. In accordance with what I briefly stated respecting the fluid secretions of the chylopoietic viscera in relation to the process of digestion, it follows that after food has been taken the fæces must contain (1) that portion of the food which has not been absorbed, and (2) the addition which is received in the form of secretion from the intestinal canal and its appendages, between the mouth and the anus. These consequently are, those substances which are altogether insoluble in the digestive fluids, as for instance, vegetable fibre; those which, although capable of digestion, have from various causes not been digested, as for instance, the flesh of old animals, sinews, ligaments, fat, &c.; the bile, more or less modified, together with biliphæin and cholesterin, the mucus of the intestinal canal, and a considerable amount of salts, amongst which ammoniaco-magnesian phosphate is especially distinguished by its well-defined crystals.

The fæces of adults are, however, different from those of the

fœtus and the infant at the breast, as the following analyses will show.

I have made an analysis of the fæces of the fœtus,—the *meconium*; it constituted a thick, glutinous greenish-black mass, had a sweetish insipid odour, and a corresponding taste: when examined with the microscope, after being diluted with water, a very large number of epithelium-cells and numerous rhombic plates, resembling crystallized cholesterin could be seen, besides a green-coloured amorphous mass which was present in considerable quantity.

A small number of minute rounded corpuscles, which upon floating about, allowed me to recognize their flattened shape, appeared to be discoloured blood-corpuscles.

Ether took up, from the dried meconium, a firm white fat, —cholesterin; alcohol took up some extractive matter with bilifellinic acid; spirit took up a substance reacting exactly like casein, together with some bilifellinic acid; finally, alcohol acidulated with sulphuric acid took up some green bile-pigment. There remained cells, mucus, and probably albumen.

100 parts of the dried meconium contained:

	Analysis 149.
Cholesterin	16·00
Extractive matter and bilifellinic acid	14·00
Casein	34·00
Bilifellinic acid and bilin	6·00
Biliverdin with bilifellinic acid	4·00
Cells, mucus, albumen	26·00

The ash of meconium consists, according to Payen, of an alkaline carbonate, and phosphate of lime.

[Dr. Davy[1] has recently examined the meconium both microscopically and chemically. "It may be advantageously examined by the microscope, either mixed with water or in a saturated solution of common salt, or merely compressed between two plates of glass. Using either method, its appearance is much the same,—it exhibits a confused mixture of globules, plates, and molecules.

"The globules, about 1-3000th of an inch in diameter, are very

[1] Medico-Chirurg. Trans. 1844, p. 189.

abundant, and form the principal mass of the whole. Judging from their form and size, their insolubility in water and alcohol, they may be inferred to consist chiefly of mucus.

"The plates, which are tolerably abundant, are of two kinds: one kind is of irregular form, somewhat granular, varying in size from about 1-2000th to 1-1000th of an inch in diameter, insoluble in water, alcohol, whether hot or cold, and the dilute acids and alkalies after the manner of epithelium-scales, which we believe them to be. The other kind are of a regular form, chiefly rhomboidal, of great thinness and perfect transparency, insoluble in water and acids and cold alcohol, but readily soluble in hot;—properties sufficiently indicative of cholesterin.

"The molecules vary in size from 1-8000th to 1-20,000th of an inch in diameter;—and, as they are insoluble in water, and in most part soluble in an alkaline ley, they may be considered as consisting chiefly of fatty matter. They constitute a very small part of the whole.

"Besides these ingredients admitting of being distinguished by the microscope, to which the meconium owes its thick consistency and viscid nature, there is another portion, the soluble part, with which they are imbued, and from which the mass derives its colour and taste, and probably its power of resisting putrefaction, and which seems identical with the colouring and sapid matter of bile, being soluble in water and alcohol.[1]

"The specific gravity of meconium, deprived of air, exceeds that of water. It sinks in a saturated solution of common salt of the specific gravity of 1148.

"This mixture of meconium and brine affords, after standing for some time, a kind of mechanical analysis or separation of its ingredients. The mucus-globules and epithelium-scales, dyed of a dark green by the colouring matter, find their place of rest at the bottom, whilst in the supernatant fluid, slightly turbid, and of a bright greenish-yellow hue, numerous plates of cholesterin, and a smaller number of fatty globules and molecules are found suspended."

[1] This property of meconium is remarkable. After more than three months a portion put by in a bottle containing a good deal of air, closed to prevent the drying of the substance, was found unaltered in colour, and presenting the same appearance under the microscope as when first examined; the only perceptible difference was that its upper surface was covered with a mould or mucor, like that of cheese, formed of connected globules, each about 1-5000th of an inch in diameter.

Every specimen examined by Dr. Davy, (some voided just after birth, others taken from the intestines of still-born children,) was very similar, composed chiefly of mucus-globules and epithelium-scales, and of biliary matter containing, besides the colouring and sapid matter of the bile, a small portion of cholesterin, of margarin, and olein, with a little free acid, probably the carbonic, judging from the absence of a precipitate on the addition of nitrate of silver, and from the circumstance that the redness imparted to litmus paper was removed by heat.

A specimen obtained from a healthy child immediately after birth, contained:

Water	72·7
Mucus and epithelium-scales . .	23·6
Cholesterin and margarin . .	0·7
Colouring and sapid matter of bile, and olein .	3·0
	100·0

A portion of the same meconium was incinerated. It burned, after becoming semifluid, with a bright flame, and left ·69% of reddish ash, chiefly peroxide of iron and magnesia, with a trace of phosphate of lime and chloride of sodium: the magnesia seemed to be the predominant ingredient and uncombined.]

I have likewise analysed the fæces of an infant six days old, nourished on its mother's milk. They were pultaceous, of a yellow colour, had a strong acid odour, and both smelled and tasted like sour milk. When the mass was diluted with water, I could observe through the microscope an extraordinary number of fat-vesicles; there were no epithelium-cells, but I found an amorphous consistent matter resembling coagulated albumen or casein. The proportion of fat was so large that on evaporation the whole mass became fluid. Ether took up this fat, which appeared to be more solid than butter, but contained no cholesterin, since it was perfectly saponifiable. After the removal of the fat, the fæces did not yield any extractive matter to alcohol, but gave biliverdin to alcohol acidulated with sulphuric acid. On extracting this colouring matter with ether, a considerable quantity of green fat was taken up.

100 parts of the dried fæcal mass contained:

	Analysis 150.
Fat	52·00
Bile-pigment with fat	16·00
Coagulated casein with mucus	18·00
Moisture and loss	14·00

No accurate analysis of the excrements of the healthy adult has been made, that I am aware of, since 1804, when Berzelius investigated the subject: I shall therefore give his results. The excrements mix very gradually with water, which they render mucous and turbid, and which is a long time clearing itself: on decanting the mixture, there remains a grayish-brown residue consisting of insoluble vegetable matter, through which a thick grayish-green fluid permeates, depositing a copious sediment when placed in a corked bottle.

The thinner supernatant portion can only be filtered with difficulty. If the fluid is very concentrated, and is at the same time clear, it will soon be observed to become dark, a change of colour apparently due to the action of the atmosphere. When this fluid is evaporated, crystals of ammoniaco-magnesian phosphate gradually form on the surface; as they were not previously apparent we may conclude that the ammonia is subsequently produced. On extracting with alcohol the residue left after the evaporation of the water, a substance of a reddish-brown colour is taken up, while a grayish-brown matter (A) remains undissolved.

The alcoholic solution yields on evaporation a residue which forms a resinous precipitate with sulphuric acid, consisting of bilifellinic acid with an excess of bilin, which may be separated by oxide of lead into bilifellinate of lead and bilin.

On distilling the mixture with sulphuric acid we obtain a fluid which yields traces of hydrochloric but not of acetic acid: on saturating the sulphuric acid in the residue with baryta, after the separation of the biliary resin, and then evaporating, and treating the dry mass with alcohol, an extractive matter of a reddish-brown tint is taken up, which is apparently the cause of the change of colour to which we have already alluded in the concentrated aqueous solution of the fæces. This substance is soluble in alcohol and in water, is almost entirely precipitated by the salts of tin, lead, and silver, and on the addi-

tion of an acid a bright red deposit is formed. On adding a little tannic acid it is precipitated in the form of a red powder, and by an excess of that reagent, in greyish-brown flocculi.

The substance (A) which is soluble in water but not in alcohol, consists of albumen coloured brown by bile, containing, mixed with it, alkaline sulphates and phosphates, and phosphate of lime.

That portion of the fæces which is insoluble in water, and remains floating on its surface, consists of a mixture of intestinal mucus and of the substances precipitated by the bile: it is very viscid, clogs up the pores of filtering paper, and dries upon it as a glistening, brittle, and elastic coating; on being again placed in water it softens, and, especially if any free alkali is present, becomes viscid as before.

This mass is perfectly soluble in caustic potash, and may be again thrown down by the addition of an acid; the fluid then gives off an odour of bile. Ether and alcohol take up fat and biliary resin, and yield greenish extracts. The ethereal solution becomes turbid on the addition of alcohol in consequence of the precipitation of fat; the residue left after evaporation melts in boiling water, leaves spots of fat on filtering paper, and dissolves in caustic potash; hence it contains no cholesterin. The portion left after the aforesaid extractions with ether and alcohol, imparts to water a peculiar yellow matter, which soon changes to a darker tint after exposure to the air; it is devoid of odour or taste, and rapidly becomes putrid. It is at first insoluble in alcohol, but it becomes soluble as decay commences; moreover when fresh it is hardly rendered turbid by the addition of infusion of galls, but is strongly precipitated by that reagent after the commencement of putrefaction. If this substance, when quite fresh, is mixed with the solution of fat and biliary resin which we have just described, we observe a grayish-green precipitate which deposits itself as slowly as the precipitate from which these substances were originally obtained. Hence, as Berzelius remarks, we may conclude that the excrements contain an insoluble combination of the constituents of the bile, with other materials which have been added to it in the course of the digestive process.

The analysis of human fæces, sufficiently consistent to form

consistent masses, yielded to Berzelius the following results in 1000 parts:

Water	733·0
Solid constituents	267·0
Bile	9·0
Albumen	9·0
Peculiar extractive matter	27·0
Salts	12·0
Insoluble residue of food	70·0
Substances added in the intestinal canal, as mucus, biliary resin, fat, a peculiar animal matter, &c.	140·0

The salts in this analysis were determined by a separate experiment: three ounces of fresh excrement were repeatedly extracted with water, and the residue obtained by evaporation was incinerated.

The ash was composed of:

Carbonate (lactate) of soda	3·5
Chloride of sodium	4·0
Sulphate of soda	2·0
Phosphate of magnesia	2·0
Phosphate of lime	4·0
	15·5

We observe that there is a considerable proportion of phosphate of magnesia, and a much larger of phosphate of lime; the former constituting 13·3% and the latter 26·6% of the salts. The comparatively large amount of phosphate of magnesia may be partly accounted for by the use of coarse bread, which contains a considerable quantity of this salt.

From dried excrements Berzelius obtained 15·0% of fixed salts, of which 10% were earthy phosphates with a trace of sulphate of lime, 0·8% carbonate of soda, an equal quantity of sulphate of soda with sulphate of potash and phosphate of soda, and 1·6% silica originating from vegetable matters. Nothing is said regarding the chlorides; they were probably not determined.

[Enderlin has instituted numerous observations on human fæces, chiefly in reference to the salts.

A. Fresh excrements of a yellowish-brown colour, a pulpy appearance, and an alkaline reaction, were dried and incinerated.

The resulting ash was white, alkaline, effervesced on the addition of an acid, and contained:

Tribasic phosphate of soda (a little).
Chloride of sodium.
Alkaline sulphates.
Phosphates of lime and magnesia (in abundance).
Carbonate and sulphate of lime.
Phosphate of iron (a trace).

B. Another portion of the same excrement was extracted with water, and the brown, alkaline solution evaporated on the water-bath.

During the process of evaporation there was formed on the surface a tenacious, yellowish-brown film, which, when removed, was speedily replaced.

a. One half of the evaporated aqueous extract was incinerated. The ash was very alkaline, effervesced briskly on the addition of an acid, and contained:

Alkaline carbonates.	Alkaline sulphates.
Alkaline phosphates.	Chloride of sodium and earthy phosphates.

b. The other half of the evaporated aqueous extract was treated with alcohol, which assumed a tint varying from a red to a green, and had an alkaline reaction. On evaporating the alcoholic solution, an alkaline ash was obtained, consisting, for the most part, of tribasic phosphate of soda and chloride of sodium.

The membrane and other matters not taken up by alcohol, yielded a neutral ash consisting of phosphates of lime and magnesia, with traces of chloride of sodium and alkaline phosphates.

c. The portion of excrement not taken up by water, yielded a neutral ash consisting of:

Phosphates of lime and magnesia.
Sulphate of lime.
Traces of chloride of sodium and alkaline phosphates.

With a solution of baryta, the alcoholic solution yielded a very bulky, yellowish-green precipitate; and, on the addition of basic acetate of lead, there was a considerable sediment soluble in acetic acid, decolorization of the fluid, &c.; hence unchanged choleate of soda was present. The occurrence of this constituent was, however, by no means invariable; and, gene-

rally speaking, choleate of soda (or bile) may be expected to be absent when the fæces have remained for some time in the large intestine, and there has been full opportunity for resorption.

It follows that the carbonate of lime is a product of the double decomposition that occurs between the sulphate of lime and the carbonate of soda resulting from the incinerated choleate of soda, or bile.

The formation of the membrane during evaporation indicates the presence of a certain amount of albumen.

In 100 parts of the ash yielded by the excrement of another individual, there were contained:

Chloride of sodium and alkaline sulphates	1·367	soluble in water.
Bibasic phosphate of soda	2·633	
Phosphates of lime and magnesia	80·372	insoluble in water.
Phosphate of iron	2·090	
Sulphate of lime	4·530	
Silica	7·940	
	98·932	

From the absence of carbonate of lime in this instance, it may be concluded that no choleate of soda or bile was present. The excrement was very firm and solid.

I am indebted to the kindness of Dr. Percy for the following analyses of the fæces.

1. The individual, who was about thirty years of age, had taken the ordinary diet of this country, and appeared to be in the enjoyment of perfect health.

In 100 parts of dried residue there were contained:

Substances soluble in ether (brownish yellow fat)	11·95
„ in alcohol of ·830	10·74
„ in water (brown resinoid matter)	11·61
Organic matter insoluble in the above menstrua	49·33
Salts soluble in water	4·76
Salts insoluble in water	11·61

An ultimate analysis of the fæces in this case was also instituted.. "I may here premise," says Dr. Percy, "that I have invariably used chromate of lead as the oxidising body, and have occasionally sheathed the combustion tube with thin sheet copper, in order to enable me to attain a high degree of heat

towards the close of the combustion, a precaution essentially necessary in the analysis of these matters, as the last trace of carbon cannot, without this precaution, be completely burned. In corroboration of this statement I may mention that the perfect incineration of fæces at a red heat requires a considerable time. The matter was prepared for analysis by first drying over the water-bath, and then either in an oven at the temperature of 212° or some degrees above, or in the salt-water bath and by a current of air desiccated by chloride of calcium. I was extremely particular in respect to the drying, and, generally, in a second analysis, employed matter which had been subjected to the drying process for a much longer time than in the first, so that the correctness of the proportion of hydrogen should be satisfactorily tested.

1st Analysis: 7·41 grs. gave—of water 4·43 or of hydrogen 6·64%, of CO_2 12·55 or of C 46·18%.

2d Analysis: 7·24 grs. gave—of water 4·44 or of hydrogen 6·81%, of CO_2 12·28 or of C 46·23%.

Incineration: 50·13 grs. gave—of ash 8·21, or 16·37%.

Nitrogen—not yet determined.

Taking the mean, we have:

C	46·20	100·00
H	6·72	
N & O	30·71	
Ash	16·37	

"These results are very nearly the same as those obtained by Dr. Playfair,[1] at Giessen. His analysis gives C 45·24, H 6·88, N & O 34·73, ash 13·15. These facts are worthy of attention, as they seem to show that, under ordinary circumstances of health, the composition of the fæces is more uniform than we might *à priori* have anticipated. The first analysis, it will be borne in mind, was of the fæces of a man in this country; the second, of a soldier at Giessen.

"2. A man undergoing the curious and rigorous discipline of training for prize-fighting. This individual, it will not be doubted, was in the possession of the most perfect health. He had been in training for about a week. Age, 22; height, 5 ft. 6 in.; weight, 8½ stones. I request particular attention to the diet. He breakfasted at 9 a.m., and took one pound of mutton weighed before cooking. He dined at 1 p.m., took the same quantity of

[1] Liebig's Animal Chemistry, 2d edition, p. 285.

mutton, and about two ounces of bread. He had the same quantity of mutton for supper at 8 p.m. At each meal he drank half a pint of ale, and no other liquid during the day; nor, it must be remembered, had he any other vegetable matter besides the small quantity of bread mentioned. He walked seventeen miles daily.

1st Analysis: 5·35 grs. gave—of HO 3·43 or H 7·12%, of CO_2 9·73 or C 49·60%.
2d Analysis: 5·74 grs. gave—of HO 3·62 or H 7·01%, of CO_2 10·52 or C 49.98%.

The difference between these two analyses, in respect to the carbon, is greater than should be allowed, but I had not time to make a third analysis.

Incineration: 31·42 grs. gave—of ash 4·56, or 14·51%.

Mean—C	49·79	100·00
H	7·06	
N & O	28·64	
Ash	14·51	

"I should observe that, in drying this specimen, towards the end of the process a small quantity of liquid condensed on the surface of the tube communicating with the vessel of water, which was clear and colourless, had a peculiar and extremely offensive odour, and which powerfully reddened litmus. I had not sufficient leisure to examine it more minutely at the time."[1]]

The fæces during disease.

In certain pathological conditions, the fæces frequently undergo very important modifications. These changes cannot be due to any peculiarities in the ingesta; they must originate in an alienated mixture or separation of the secretions of the chylopoietic viscera. This irregularity may lead to imperfect chymification, in which case matters will be carried off with the fæces, which, if they had been properly digested, would have entered the vascular system; or, in consequence of the changed process of secretion, substances which are normal secretions may be separated in too large a quantity, as, for instance, water; or substances which ought to be present, are entirely

[1] I strongly suspected the matter to be butyric acid, and my suspicion has since been much strengthened by my examination of a specimen of pure butyric acid which I had an opportunity of seeing in London, at the Pharmaceutical Society. Besides, Dr. Erwin Waidele, whom I had the pleasure of meeting at Professor Graham's, informed me that Dr. Ragsky of Vienna has discovered this acid in the fæces.

absent, as, for instance, bile; or, lastly, substances which are altogether foreign to the normal secretions, are mixed with the fæces, as albumen, blood, &c.

In the case of diabetes alluded to in p. 296, I carefully examined the fæces. They contained no sugar, and were chiefly remarkable for their large amount of solid fat. Two or three pultaceous stools, averaging collectively 18·5 ounces, were passed daily. They gave off a very disagreeable odour, and were of a grayish clay colour.

Alcohol digested with this fæcal matter became coloured brown, and extracted a large quantity of fat, extractive matter, and a little bilin. On treating the portion insoluble in alcohol with water, a small amount of water-extract, almost devoid of taste, was taken up. The insoluble residue yielded, on incineration, an odour of burned horn or glue, and contained a large amount of nitrogen.[1] A quantitative analysis showed that the 18·5 ounces of fæcal matter contained:

	Analysis 151.			
	Whole quantity.			In 100 parts.
	oz.	grains.		
Water	12	312		
Solid constituents . . .	5	408		
Fat	2	0		34·0
Bilin and extractive matter soluble in alcohol . . .	0	56		2·0
Water-extract . . .	0	56		2·0
Alkaline salts . . .	0	182	364	6·5
Carbonate of lime . . .	0	70		2·5
Earthy phosphates and peroxide of iron .	0	112		4·0
Insoluble nitrogenous matters .	2	359		47·0

I have attempted, in accordance with the plan laid down in the appendix to Liebig's 'Animal Chemistry,' to compare the amount of carbon, nitrogen, and hydrogen in the food and in the excretions.

The ingesta consisted of:

8	oz. of	dry gluten bread.
11·5	„	dry meat.
2	„	dry egg.
2	„	cod-liver oil.
23·5 ounces.		

[1] [This is entirely opposed to the experience of Lehmann, who states that the fæces of diabetic patients frequently yield a mere trace of nitrogen. Lehrbuch der physiologischen Chemie, 1842, p. 312.]

There were discharged:

By the urine.	From the bowels.
8·8 oz. of sugar.	2 oz. of fat.
1·3 oz. of urea.	2·5 oz. of nitrogenous insoluble fæcal matter & protein-compounds.
15 grains of uric acid.	100 grains of extractive matter & bilin.

15 ounces.

There is then an excess of $8\frac{1}{2}$ oz. of food.

In the food there are contained;	In the excretions there are contained:
12 oz. of carbon.	6·6 oz. of carbon.
1 oz. 6 drms. of hydrogen.	1 oz. of hydrogen.
2·5 oz. of nitrogen.	410 grains of nitrogen.
700 grains of fixed salts.	710 grains of fixed salts.

Hence there are carried off, by respiration and transpiration, 5·5 ounces of carbon, 0·75 of hydrogen, and 1·62 of nitrogen.

This quantity of carbon and hydrogen is much less than is generally supposed to be carried off by the lungs; and with respect to the nitrogen, although we may assume that some is carried off by the skin, the disproportion is still very great. An accurate examination of the expired air might throw much light on this obscure and remarkable morbid process.

[I am indebted to Dr. Percy for the following analyses of diabetic fæces:

1. "Fæces of a boy aged 7 years. It was found impossible in this case to enforce a rigid system of animal diet, so that we may regard these fæces as the fæces of diabetes unchecked or modified by treatment. They were hard, and not of the natural consistence of health.

1st Analysis: 5·44 grs. gave—of HO 3·35 or H 6·83%, of CO_2 8·76 or C 43·94%.
2d Analysis: 4·72 grs. gave—of HO 3·01 or H 7·09%, of CO_2 7·58 or C 43·79%.
Incineration: 30·76 grs. gave—of ash 6·18, or 20·09%.

Mean—C	43·86	100·00
H	6·96	
N & O	29·09	
Ash	20·09	

The proportion of saline matter is here much greater than usual, and, doubtless, depended upon constipation.

The fat taken up by ether amounted to 16·16% of the dried fæces.

2. "The fæces of a man (Flint) aged 48 years, who was labouring under diabetes of long standing. He was restricted principally to animal food, a small quantity of bread only being allowed. Consistence moderate. This analysis was executed under my own supervision by my former pupil, Mr. Stallard.

1st Analysis: 8·22 grs. gave—of HO 5·61 or H 7·58%, of CO_2 16·43 or C 54·51%.
2d Analysis: 8·57 grs. gave—of HO 5·84 or H 7·57%, of CO_2 17·03 or C 54·20%.

The nitrogen was determined by Wills's method.

Nitrogen: 6·29 grs. gave—of metallic platinum 5·33 grs., which corresponds to 12·01% of nitrogen.

Incineration: 61·01 grs. gave of ash 5·71, or 9·36%.

Mean—C	54·35	100·00
H	7·57	
O	16·71	
N	12·01	
Ash	9·36	

Proximate Analysis:

Substances soluble in ether	22·00	100·00
" alcohol	11·13	
" water	12·02	
Organic matter, insoluble in these menstrua	45·49	
Ash	9·36	

3. "Fæces of the same individual some weeks afterwards, while taking about three ounces of fat bacon daily, in addition to his usual animal diet. It was evident after drying, that these fæces abounded in fat from their appearance on the application of heat. It was impossible to reduce them *per se* to fine powder.

1st Analysis: 5·06 grs. gave—of HO 4·22 or H 9·22%, of CO_2 11·20 or C 60·36%.
2d Analysis: 6·28 grs. gave—of HO 5·25 or H 9·28%, of CO_2 13·89 or C 60·32%.
Incineration: 55·93 grs. gave—of ash 7·40, or 13·23%.

Mean—C	60·34	100·00
H	9·25	
N & O	17·18	
Ash	13·23	

Ether took up a quantity of fat amounting to 51·55% of the dried fæces.

4. "Fæces of the same individual a few weeks afterwards, while restricted to an animal diet of the lean of meat: as far as it was practicable all fat was removed.

1st Analysis: 7·06 grs. gave—of HO 5·05 or H 7·95%, CO_2 13·72 or C 53·00%.
2d Analysis: 6·62 grs. gave—of HO 4·77 or H 8·00%, CO_2 12·93 or C 53·27%.
Incineration: 16·81 grs. gave—of ash 2·96, or 17·60%.

Mean—C	. . .	53·09	100·00
H	. . .	7·97	
N & O	. .	21·34	
Ash	. . .	17·60	

5. "Fæces of a man (Roberts)[1] between 30 and 40 years, labouring under diabetes of some standing. Diet, exclusively animal, with the exception of a small quantity of bread.

1st Analysis: 4·53 grs. gave—HO 3·07 or H 7·53%, CO_2 7·64 or C 45·99%.
2d Analysis: 5·33 grs. gave—HO 3·67 or H 7·65%, CO_2 8·92 or C 45·64%.
Incineration: 50·84 grs. gave—of ash 10·77, or 21·18%.

Mean—C	. . .	45·81	100·00
H	. . .	7·59	
N & O	. .	25·42	
Ash	. .	21·18	

6. "Fæces of the same individual, some weeks afterwards, while on a mixed diet. At this time also he was much emaciated and exhausted, in consequence probably of having been obliged to work, and to subsist on a mixed diet.

1st Analysis: 5·13 grs. gave—of HO 3·36 or H 7·28%, CO_2 8·63 or C 45·88%.
2d Analysis: 4·86 grs. gave—of HO 3·18 or H 7·27%, CO_2 8·21 or C 46·07%.
Incineration: 32·31 grs. gave—of ash 7·14, or 22·10%.

Mean—C	. . .	45·97	100·00]
H	. . .	7·27	
N & O	. .	24·66	
Ash	. . .	22·10	

In dysentery the stools are thin, contain flocculent mucus, and are either almost colourless or milky, (dysenter. catarrh.) or they are coloured red by blood (dysenter. inflammat.). According to Schönlein they possess a peculiar smell quite characteristic of the disease.

On examining the white or slightly coloured mucous fluid under the microscope, we observe numerous mucus-corpuscles floating about in it: the red, sanguineous discharges also contain an extraordinary number of mucus-corpuscles, numerous blood-corpuscles, but no (or very few) epithelium-scales.

We sometimes find pseudo-membranous portions of exuded plastic lymph mixed with the stools, especially in the most inflammatory forms of the disease.

[1] Roberts's case has been published in the Medical Gazette. He has since died, and the sequel will shortly appear, together with the cases of the child affected with diabetes, and of the other patient Flint.

In typhous diarrhœa the motions are frequently very bulky, of a chocolate colour, frothy, mixed with black dissolved blood, and not giving off the peculiar odour of dysenteric evacuations, but rather a cadaverous smell. In bilious diarrhœa the bile-pigment is mixed with the fluid motions, which are less copious than in the former case.

In enteritis mucosa the stools, especially those which are discharged during the night, are thin, and, in addition to the mucus and fæcal matters coloured yellow by bile-pigment, contain a peculiar flocculent mass, like exuded lymph, which, on more accurate examination, seems to consist of purulent and fatty matter. Blood is likewise sometimes found in these stools.

In abdominal typhus the stools are very characteristic; in the first stage they do not differ very much from the normal state; they are sometimes very firm, sometimes very thin and watery. In a more advanced stage of the disease, they separate when shaken in a glass vessel into two strata; the lower one forms a slightly yellow flocculent mass, while the upper one is composed of a cloudy, whey-like fluid. On examining the flocculent material under the microscope, I found that it was composed, for the most part, of small lumps of mucus or pus, of an amorphous yellow matter—probably coagulated albumen with bile-pigment, of a comparatively small quantity of epithelium, and sometimes of extremely numerous and beautifully formed crystals of ammoniaco-magnesian phosphate, such as are depicted in fig. 27: sometimes we find, as also in phthisis intestinalis, small white masses about the size of a millet, or half as large as a hempseed; they are easily triturated and then have a greasy appearance; when examined under the microscope they appear to be composed of cells similar to primary cells or what are called the globules of inflammation. The contents of these spherical cells, which are inclosed in a very delicate membrane, are coarsely granulated and escape on the least pressure.

In some of the larger parent cells, I found smaller cells with nuclei. I dried a portion of the flocculent precipitate; on incinerating the residue I obtained 32% of salts, of which nearly one half, namely, 14·6 were earthy phosphates.

The whey-like fluid which is above the sediment, is usually tolerably rich in albumen. It coagulates, or at any rate becomes turbid on the application of heat or nitric acid. In

most cases it has a strong alkaline reaction, and contains a large amount of carbonate of ammonia, which frequently interferes with the action of heat on the albumen.

In some cases I observed that a beautiful rose-red tint was produced by the addition of nitric acid, of which I shall speak more fully in my observations on the stools in cholera. Typhous stools are sometimes tinged with blood.

In melæna blackish pitchy blood is mixed with the fæces, which sometimes consist entirely of that substance. I have previously described the peculiarities of the blood. (See Vol. I, p. 317.)

In catarrhus intestinor. the intestinal mucous membrane acts very much the same as the mucous membrane of the respiratory organs in pulmonary catarrh. The secretion is at first checked, then very much increased, and, finally, after secreting thick and tough mucus, returns to its normal condition.

In simple diarrhœa a thin muco-aqueous yellow, or yellowish-brown discharge follows the evacuation of the true fæces.

In bilious diarrhœa the stools are also liquid, but they are generally of a greenish colour, and possess so strong an acid reaction as to produce excoriation of the anus.

In dysenteric diarrhœa a large quantity of gray or greenish mucus tinged with blood, is discharged. In diarrhœa lactantium, masses are discharged which are not unlike chopped eggs: they have a strong acid odour, and exert a corroding effect on the vicinity of the anus.

In Asiatic cholera it is well known that an extraordinary quantity of watery fluid is discharged by the intestines.

Dulk found that the evacuations in cholera had an alkaline reaction, that they contained albumen, and that they were entirely devoid of the ordinary odour of fæces.

Hermann,[1] on the contrary, found that they had an acid reaction, and resembled the vomited matter, in which he detected free acetic acid. The ordinary reaction of the stools in cholera is, however, alkaline, and this was observed in a very severe case of sporadic cholera that fell under my own observation.

According to Vogel's observations, the stools in this disease resemble turbid whey: the fluid has a powerful alkaline reaction, and effervesces on the addition of an acid. On distilling a por-

[1] Poggend. Annalen, vol. 22, p. 161.

tion of the fluid he obtained in the receiver a liquid with an alkaline reaction, and having a fishy odour. On the addition of nitric acid this liquid assumed a beautiful red tint, which it retained during evaporation. The fluid, when concentrated, had an intense red colour, but was devoid of odour, which only became again apparent on neutralizing the free acid by an alkali.

The portion that remains in the retort after the distillation of the fluid contains traces of albumen, some intestinal mucus, the ordinary salts of the animal fluids, and a large amount of carbonate of soda.

Wittstock's researches respecting the fæcal discharges in cholera, coincide in most points with those of Vogel: he observed the beautiful rose-red tint that was produced by the addition of nitric acid, and he ascribed it to the presence of an urate; it is however known, that the formation of purpurate of ammonia or murexid from uric acid, requires a greater degree of concentration of the reacting substances, and a heightened temperature.

The fæces of a woman who had a very severe attack of sporadic cholera, (whose blood and urine I likewise analysed,) formed a turbid and colourless fluid, which had a strong alkaline reaction, and effervesced on the addition of acids, giving off carbonic acid and sulphuretted hydrogen, which, in all probability, arose from carbonate of ammonia and sulphuret of ammonium (hydrosulphate of ammonia).

When allowed to stand for some time it formed a sediment, which consisted, for the most part, of mucus-corpuscles, with some crystals of ammoniaco-magnesian phosphate. No epithelium cells were observed. On treating the fluid with nitric acid, effervescence took place, and flocculi of coagulated albumen separated themselves; moreover, the fluid in a short time became of a rose-red colour,—a phenomenon that was induced more rapidly by gentle warmth: when strongly heated for some time the colour entirely disappeared.[1]

The quantitative analysis of the fæcal discharge in this case gave the following results, calculated for 1000 parts:—

[1] [In an examination of the fæces in cholera, instituted by Heller, (Archiv i, p. 18,) a similar reaction was observed. The exact nature of the change that the bile-pigment undergoes in such cases is not clearly understood.]

	Analysis 152.
Water	980·00
Solid constituents	20·00
Fat	0·08
Extractive matter . . .	4·80
Albumen and mucus . .	0·52
Chloride of sodium, lactate and acetate of soda, and alkaline phosphates .	13·40
Phosphates of lime and magnesia .	0·60

This analysis bears out the result of the investigation of the blood, given in Vol. I., page 326.

Landerer[1] has analysed the fæcal evacuations of a child suffering from diarrhœa infantilis. It was a yellow fluid, with an acid and bitter taste, and its specific gravity was 1038·2. Landerer found in it: carbonate of lime 1·50; phosphate of lime 2·00; chloride of calcium 1·50; chloride of magnesium 2·45; chloride of sodium 2·43; sulphate of lime 1·50; sulphate of magnesia 0·80; bilin, butyric acid, and extractive matter 3·00; spirit-extract 1·00; free lactic and hydrochloric acids 1·00.

In enterophthisis, the fæcal evacuations likewise separate into two strata: the lower is flocculent, and when examined under the microscope is seen to consist of mucus- or pus-corpuscles mingled with remnants of food, or with an amorphous mass tinged with pigment. Sometimes we find, in the deposit from these evacuations, small white or yellow masses, which consist of cells, and can be easily crushed (such as I have already described in speaking of the evacuations in typhus), and mixed with them there are numerous fat-vesicles. A little blood is not unfrequently observed in these stools; they then have a chocolate or dark blood-red tint. The supernatant fluid is turbid, and of a yellow, brown, or bloody tint; it always contains a considerable amount of albumen.

In icterus the fæces are generally devoid of all the constituents of the bile: they are consequently of a white or grayish white colour; they are usually very firm, and deficient in moisture.

[I am indebted to Dr. Percy for the following ultimate analysis of the fæces in jaundice.

[1] Journal f. prakt. Chemie, 1841, vol. 17, p. 62.

A young woman affected with jaundice in a mild form, depending probably on functional derangement of the liver. The fæces were brown, and not clay-coloured, as in severe jaundice.

1st Analysis—5·59 grs. gave of HO 3·66 or H 7·27%, CO_2 9·69 or C 51·42%.
2d Analysis—5·12 grs. gave of HO 3·37 or H 7·31%, CO_2 9·69 or C 51·61%.
Incineration—28·18 grs. gave of ash 3·41 grs., or 12·10%.

Mean—		
C	51·51	100·00[1]
H	7·29	
N & O	29·10	
Ash	12·10	

A physician of this city sent me a white, roundish, easily compressible mass, resembling caseous matter, which had been evacuated after an ordinary motion, by a lady who was suffering from bilious sensations. When observed under the microscope, this substance, which emitted a rather disagreeable odour, was found to be composed of an extraordinary quantity of fat

[1] The following table shows, at a glance, the results of the preceding ultimate analyses:

—	Man in health. Ordinary diet.	Man in training.	Child. Diabetes.	Flint. Diabetes.	Flint. Diabetes.	Flint. Diabetes.	Roberts. Diabetes.	Roberts. Diabetes.	Girl with Jaundice.
	1.	2.	3.	4.	5.	6.	7.	8.	9.
C	46·20	49·79	43·86	54·35	60·34	53·09	45·81	45·97	51·51
H	6·72	7·06	6·96	7·57	9·25	7·97	7·59	7·27	7·29
N & O	30·71	28·64	29·09	28·72	17·18	21·34	25·42	24·66	29·10
Ash	16·37	14·51	20·09	9·36	13·23	17·60	21·18	22·10	12·10
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

TABLE of COMPOSITION, exclusive of ASH.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
C	55·24	58·24	54·88	59·96	69·53	64·43	58·11	59·01	58·60
H	8·03	8·25	8·70	8·35	10·66	9·67	9·62	9·33	8·29
N & O	36·73	33·51	36·42	31·69	19·81	25·90	32·27	31·66	33·11
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

arranged in a structureless, albuminoid mass; no tissues or cells were detected. The mass, when heated, gave off a very strong odour of butyric and acetic acids; it melted and burned with a clear flame. Alcohol extracted a very large amount of fat, consisting of margarin, olein, and butyrin, with their acids, which partially separated on cooling. In the separated flocculi I detected, with the aid of the microscope, crystals of margaric acid, but none of cholesterin. After the evaporation of the alcohol, water dissolved some butyric and acetic acids from the residue.

The portion insoluble in alcohol was digested for a considerable time in dilute acetic acid, and was precipitated from this solution by ferrocyanide of potassium.

Water did not extract any matter that was precipitable by the last-named reagent.

On incineration a considerable amount of ash was left which had an acid reaction, did not effervesce with acids, and consisted almost entirely of earthy phosphates: it contained no sulphates.

Calomel stools.

In certain morbid conditions of the system calomel is frequently given in considerable quantity: its administration is succeeded by numerous, very green, bilious stools. I endeavoured to determine by an experiment whether the bile and its pigment is the actual cause of the colour of these evacuations. The fifth stool that was passed after the administration of a large dose of calomel, was made the subject of the analysis. It was fluid, perfectly green, had no fæcal odour, exhibited a mild acid reaction, and showed, under the microscope, a great number of mucus-corpuscles and epithelium-cells. On evaporation it gave off an odour resembling that of saliva or extractive matter under similar circumstances. Ether extracted from the solid residue a considerable amount of fat which had an acid reaction, contained cholesterin, and was coloured with biliverdin. All other substances which were separated from it by water and alcohol were more or less coloured by bile-pigment.

Bilin with bilifellinic acid and biliverdin were found in large quantity; by digestion with sulphuric acid the bilin became entirely converted into biliary resin. From a quantitative

analysis it appeared that 100 parts of the solid residue of this evacuation were composed of:

	Analysis 153.
Green fat containing cholesterin	10·0
Salivary matter soluble only in water, and slightly precipitated by tannic acid and acetate of lead	24·3
Bilin with bilifellinic acid and biliverdin, collectively soluble in anhydrous alcohol	21·4
Extractive matter soluble in spirit	11·0
Albumen, mucus, and epithelium-scales	17·1
Salts	12·9
	100·0

Various attempts that I made (by Smithson's method) to detect mercury in calomel-stools proved unsuccessful.

[Dr. Golding Bird has published an analysis of the green evacuations so frequently observed in children. The specimen examined by him "was passed by a hydrocephalic infant whilst under the influence of mercury, and presented the following characters. It was a dirty-green turbid fluid which, by repose in a glass vessel, separated into three very distinct portions;—1, a supernatant fluid, of oil-like consistence, presenting a brilliant emerald-green colour; 2, a dense stratum of mucus, coagulated albumen, and epithelial debris, mixed with red particles of blood; 3, a deposit, occupying the lower part of the vessel, of large crystals of ammoniaco-magnesian phosphate, in fine prisms of an apple-green colour.

The supernatant emerald-green fluid was decanted for examination.

A. It was faintly alkaline, possessed a broth-like odour, and a density of 1020.

B. The addition of a few drops of nitric acid did not alter the colour, even after ebullition. A larger quantity of the acid being added whilst the mixture was boiling, converted the emerald-green colour into a pinkish-yellow; the green colour was not restored by the subsequent addition of an alkali.

C. Acetic acid scarcely affected the green fluid, producing no apparent coagulation of mucus.

D. A solution of acetate of lead threw down a copious grayish-green, tenacious precipitate, leaving the supernatant fluid colourless.

E. Bichloride of mercury produced a light-green precipitate, leaving the supernatant fluid pale, but not decolorizing it.

It was analysed in the following manner:

1. 1000 grains of the green fluid left, by careful evaporation, a deep olive-green, highly deliquescent extract, weighing 100 grains.

2. This extract, on being immersed in alcohol of ·837 formed a mass like birdlime, which could not be mixed with the spirit. Even after long boiling, it appeared hardly to diminish in bulk. The clear tincture being decanted left, however, an extract weighing 30 grains. This residue possessed the yellowish-green colour of faded leaves, an odour of fresh broth and a sweet sub-astringent taste, with a very slight admixture of bitterness.

3. The alcoholic extract being carefully incinerated, left 5·5 grains of ash, consisting chiefly of chloride of sodium mixed with mere traces of tribasic phosphate of soda ($3NaO, PO_5$). It was alkaline, but did not effervesce with acids.

4. The portion left undissolved by boiling alcohol yielded to water 13 grains of nearly tasteless matter which, by incineration, left a powerfully alkaline ash weighing 1·75 grains, not effervescing with acids, and consisting nearly exclusively of alkaline tribasic phosphate of soda.

5. The residue insoluble both in water and alcohol weighed 57 grains, and consisted almost entirely of coagulated albumen, dry mucus, and modified blood. It left by incineration one grain only of ash, consisting almost wholly of black-red peroxide of iron.

The following is a view of the results of the examination:

Alcoholic extract	Organic	24·50
	Inorganic	5·50
Aqueous extract	Organic	11·25
	Inorganic	1·75
Insoluble matter	Organic	56·00
	Inorganic	1·00
Water and volatile matter		900·00
		1000·00

The organic portion of the alcoholic extract consisted chiefly

of fatty matter, cholesterin, and a green substance probably identical with biliverdin; with these were traces of bile barely sufficient to communicate a bitter taste to the extract, and in too small a quantity to leave any carbonate of soda in the residue of incineration. The aqueous extract consisted chiefly of ptyalin and the extractive matters comprehended under the general term of "extrait de viande," by Berzelius. The composition of the fluid part of the green evacuation may therefore be thus expressed:

Water	900·00
Biliverdin, alcoholic extract, fat, cholesterin, with traces of bile	24·50
Ptyalin, aqueous extract coloured by biliverdin	11·25
Mucus, coagulated albumen, and hæmatin	56·00
Chloride of sodium, with traces of tribasic phosphate of soda	5·50
Tribasic phosphate of soda	1·75
Peroxide of iron	1·00
	1000·00

Professor Kersten of Freiberg has recently published a paper on the cause of the green evacuations observed after a course of the Marienbad waters for fifteen or twenty days.

The occurrence of these evacuations is regarded as critical and highly favorable. Kersten denies that the tint is in any degree dependent on the presence of bile, and ascribes it to the formation of green sulphuret of iron.

In the paper referred to he first shows that on the addition of very dilute hydrochloric acid to an evacuation of this nature diluted with thrice its weight of water, there is a development of sulphuretted hydrogen, indicating the presence of a metallic sulphuret; moreover, on the addition of ferrocyanide of potassium to the filtered acid solution a bright blue precipitate is observed, which becomes darker after exposure to the air, indicating the existence of protoxide of iron. This experiment shows that the green pigment is destroyed or decomposed by dilute hydrochloric acid, and further, that it is a compound of sulphur and iron. He accounts for the presence of the sulphuret of iron in this way. The sulphate of soda present in the water is reduced in the stomach to a sulphuret of sodium by the deoxidising power of the organic matters with which it is in contact, aided by a temperature favorable to such a change.

The bicarbonate of iron in the water is decomposed at the temperature of the stomach, and the iron precipitated either as a protoxide or as a hydrated peroxide, and immediately redissolved by the free acid of the gastric juice. This reacts on the sulphuret of sodium, and sulphuret of iron is the result.

Since the publication of Kersten's paper, a very similar view has been propounded by Dr. Bley, namely, that the green evacuations observed after the use of calomel are dependent not on the presence of bile, but of sulphuret of mercury. Unfortunately for this theory the mercury cannot be detected by analysis, and Pettinkofer's test reveals the presence of bile.

Dr. Frankl has published a paper containing various arguments in opposition to Kersten's views, and criticising his conclusions.

Berzelius, on the other hand, writes thus: "It never entered my mind to suspect that this coloration arose from sulphuret of iron, but I always believed that it might be attributed to the black oxide of iron. It is, however, quite natural that as sulphuretted hydrogen is usually produced during the progress of digestion, the oxide of iron present in the intestinal canal should be reduced to a sulphuret, no matter whether sulphates have been given or not."

Berzelius renders Kersten's view more general, observing "that every chalybeate water, whether it contain sulphates or not, produces a similar appearance in the evacuations." On this Kersten remarks: that "the coloration may be most intense when sulphates are present, because by their decomposition during digestion an excess of sulphuretted hydrogen will be generated."]

Vomitus. (*Matters discharged by vomiting.*)

It is well known that the fluid which is found in the stomach, and which is a mixture of gastric juice, saliva, and remnants of food, becomes much changed in its properties in certain morbid conditions of the system. I need scarcely refer to the excess of free acid, and to the presence of bile in certain conditions of the stomach. On the occurrence of the latter of these states we usually observe a separation, or peeling off, of the upper

stratum of epithelium-scales from the tract of mucous membrane between the pharynx and the stomach, and this condition is recognized by the gastric furred tongue.[1]

This fur or coating has been analysed by Denis: he found that one half consisted of phosphate and carbonate of lime, the other half of mucus.

In gastrodynia, even when there is no food in the stomach, the gastric juice is secreted in such an acid condition as to set the teeth on edge. This is chiefly caused by free hydrochloric acid, but concentrated lactic and acetic acids will produce the same effect.

In gastritis, colonitis, enteritis, and peritonitis, a grass-green liquid is often brought up; it is frequently mixed with green or white flocculi, and on other occasions is quite clear; it almost always has an acid reaction, and usually contains a considerable amount of fat.

I analysed a fluid of this sort that was vomited during peritonitis: it had a greenish, viscid appearance, and contained whitish flocculi that presented an amorphous character under the microscope. It did not affect blue or red litmus paper; on the addition of nitric acid there was a separation of white flocculi, and the fluid became first of a pale blue and subsequently of a reddish tint. On the application of heat some globules of oil separated themselves, and a small quantity of albumen became coagulated; it contained 2·9% of solid constituents, from which ether took up a yellow liquid fat that was imperfectly soluble in cold, but dissolved easily in hot alcohol; it contained a little cholesterin, and gave off a smell like that of a fatty acid.

Alcohol took up extractive matter and bilifellinic acid, which latter could be separated by means of sulphuric acid; dilute alcohol took up spirit-extract with a little bilifellinic acid. A considerable amount of the portion that was insoluble in spirit dissolved in water, and was again precipitated by alcohol, tannic

[1] On examining the thick coating of the tongue in cases of abdominal typhus, I have found that it is composed of matted epithelium-scales over which minute sporules are scattered. The sordes from the teeth exhibited similar characters.

acid, and acetate of lead. The precipitate thrown down by alcohol was soluble in an excess of water, which was rendered turbid by the addition of acetic acid, and yielded a copious precipitate on the subsequent addition of ferrocyanide of potassium.

As the ash, after incineration, consisted of carbonate of soda, I regarded the substance insoluble in alcohol as an albuminate of soda.

The quantitative analysis of this "vomitus æruginosus seu herbaceus" yielded the following proportions in 1000 parts:

	Analysis 154.
Water	971·0
Solid residue	29·0
Fat	4·3
Bilifellinic acid, alcohol-extract, and bile-pigment	1·5
Spirit-extract with a little bilifellinic acid	11·4
Albuminate of soda	5·4
Mucus and albumen	5·8

[Heller[1] analysed a brilliant green fluid vomited by a young woman aged 20 years, suffering from peritonitis.

In quantity it amounted to about three ounces; it was slightly turbid, and threw down an inconsiderable sediment which was viscid, more of a yellowish tint than the supernatant fluid, and consisted of epithelium-cells and mucus-corpuscles.

The fluid had an acid reaction, but contained neither free hydrochloric nor acetic acid. Its specific gravity was 1006. On the addition of nitric acid it first became blue, and afterwards of a beautiful carmine red. It contained no albumen.

In 1000 parts there were contained:

Water	990·50
Solid constituents	9·50
Fat	0·24
Water-extract	1·30
Biliverdin with a little biliphæin and a trace of alcohol-extract	5·38
Fixed salts	3·75

The salts consisted for the most part of the chlorides of sodium and calcium, associated with less quantities of phosphate of soda, sulphate of potash, and earthy phosphates. Urea and uric acid were sought for without success.

[1] Archiv, vol. 1, p. 226.

The green colour seems undoubtedly due to the presence of biliverdin, which is probably formed in the stomach by the action of the acid solution of hydrochlorate of lime on the biliphæin. Hence the occurrence of green vomiting need not be regarded as indicative of any peculiar morbid change.

A brief notice of a green fluid vomited during an attack of sporadic cholera, may be found in vol. 1, p. 18, of Heller's Archiv.]

Vomitus with urinary constituents.

It is stated that in those cases in which the formation and excretion of the urine are impeded its constituents are discharged with vomited matters.

Nysten[1] and Barruel had an opportunity of analysing a vomited fluid which contained urea, uric acid, and the ordinary urinary salts.

[Dr. Halliday Douglas has reported a case in which urea was detected in the vomited fluid. London and Edinburgh Monthly Journal of Medical Science, vol. 1, p. 410.]

Vomitus in carcinoma.

In carcinoma of the stomach a fluid is vomited which deposits masses of chocolate or coffee-coloured flocks on the bottom of the vessel, while others are observed on the surface of the fluid. On examining a few of them under the microscope we observe a considerable quantity of large rounded cells with yellow granular contents, and also a very great number of fat-vesicles, some larger and others smaller than the cells. Remnants of food, and especially undigested starch-granules, are likewise frequently observed. The latter may be easily mistaken for fat-vesicles, but moderately strong compression causes their envelopes to break, and on the addition of a solution of iodine they assume a blue colour. By this test all ambiguity is avoided.

[Dr. George Wilson has published a notice of the chemical and microscopical characters of the fluid ejected in pyrosis—

[1] Journ. de Chem. Med. 1820, Ser. III, p. 257.

the ordinary water-brash. The most remarkable of these is the appearance of a microscopic cryptogamic plant (*sarcina ventriculi*), and of acetic, lactic, and carbonic acids in the liquid. The first case in which these were found, occurred to Mr. Goodsir, and was published by him in the 'Edinburgh Medical and Surgical Journal' for April 1842. Since that period a case has occurred in the practice of Mr. Benjamin Bell of Edinburgh, who allowed Mr. Goodsir and Dr. Wilson to examine the fluid ejected by his patient, in which the same organism and acids were discovered; and Mr. Busk, of the Dreadnought hospital ship, Greenwich, has published the history of three cases where the *sarcina* presented itself, but no analysis was made of the fluids in which it appeared.

On examining the fluid with the microscope, the sarcina is found to present the following characters.[1] In every instance the organisms presented themselves in the form of square or slightly oblong transparent plates, of a pale yellow or brown colour, and varying in size from the 800th to the 1000th of an inch. They were made up of cells, the walls of which appeared rigid, and could be perceived passing from one flat surface to another as dissepiments. These dissepiments, as well as the transparent spaces, were, from compression of contiguity, rectilinear, and all the angles right angles; but the bounding cells bulged somewhat irregularly on the edges of the organism, by reason of the freedom from pressure. These circumstances gave the whole organism the appearance of a woolpack, or of a soft bundle bound with cord, crossing it four times at right angles, and at equal distances. From these very striking peculiarities of form, Mr. Goodsir has proposed for it the generic name of SARCINA.[2]

On examining the ejected fluid in the case recorded by Mr. Goodsir, it was found to possess the following characters. It was thick and viscid; on standing, it deposited a large quantity of ropy matter mixed with portions of undigested food, and, when filtered through paper, had a pale brownish yellow colour, and was quite transparent. It still contained much animal

[1] The reader is referred to the 'Edinburgh Medical and Surgical Journal' for April 1842, for a more minute description of the sarcina, and a detailed account of the chemical analysis of the liquid containing it.

[2] *Sarcina*, a pack or woolpack.

matter in solution, becoming opaque and flocculent when boiled, and giving a very copious precipitate with infusion of galls. It also precipitated nitrate of silver densely, and, when evaporated to dryness and exposed to a full red heat in a platinum crucible, left an ash containing much chloride of sodium. It reddened litmus powerfully, and effervesced sharply with alkaline carbonates. It continued strongly acid after being twice distilled, and did not precipitate nitrate of silver, but retained the sour smell, which could now be recognized as identical with that of vinegar. On neutralizing the twice distilled fluid with lime-water, and evaporating to dryness, a salt was obtained, which, on being decomposed in a tube-retort with sulphuric acid, yielded a volatile odorous acid, readily identified by several tests with the acetic.

It was found by several trials, that, on an average, an ounce of the liquid neutralized 0·4 grain of carbonate of potash; a quart (32 oz.) would therefore neutralize 12·8 grains, which correspond to 9 grains of the hydrated (crystallizable) acetic acid, $C_4 H_3 O_3 + HO$. The liquid remaining in the retort continued to redden litmus powerfully after all the acetic acid had been distilled from it. This was traced in part to the presence of a small quantity of free hydrochloric acid; but it was chiefly owing to the existence in the liquid of a considerable proportion of lactic acid. The most remarkable feature of this case, in a chemical point of view, was the large quantity of acetic acid found; the quantity of liquid ejected at once by the patient often amounted to more than two quarts, which would contain 18 grains of acetic acid. In Mr. Bell's case the chemical characters of the liquid were very similar. An additional point was, however, ascertained, namely, the presence of free carbonic acid in the liquid.]

CHAPTER XI.

THE COMPONENT PARTS OF THE ANIMAL BODY.

The Bones.

The bones are the least destructible of all the parts of the organism. Under favorable circumstances they remain as unchanged as mere inorganic matter, and the amount of cartilage has been found unaltered in bones three thousand years old.[1]

The external surface of bone is surrounded by a membrane richly endowed with nerves and vessels—the periosteum, which, as well as the cartilaginous portion, can be converted, by boiling, into gelatin. The interior of the cylindrical bones is lined in a similar manner: the flat and short thick bones are, however, filled in the interior with delicate lamellæ arranged so as to present a cellular appearance: in the flat bones, this is termed the diplöe. If a bone is suspended in dilute hydrochloric acid at a low temperature, all the earthy matter becomes gradually dissolved and the mere cartilage remains, retaining the precise form of the original bone. It is supple, transparent, and soft, but on drying it becomes of a darker colour, hard, and somewhat contracted. When boiled it becomes rapidly converted into gelatin, leaving the fibrous tissue and the vessels of the bone unacted on. These vessels may be exhibited by leaving the bone in dilute hydrochloric acid till about one half of the earthy matter is dissolved: it must then be washed with

[1] This has been observed in the bones of human and animal mummies discovered in Egyptian sepulchres. Apjohn and Stokes found in the bones of an extinct gigantic elk, 48·87 of ordinary cartilage, combined with 43·45 of the phosphates of lime and magnesia with fluoride of calcium, and 9·14 of carbonate of lime, &c. In the teeth of an Egyptian mummy, Lassaigne found 29⅜ of organic matter; and in the teeth of a fossil bear, 14 of cartilage and 70 of phosphate of lime. Gimbernat prepared an edible jelly from the bones of the Ohio mammoth.

cold water, and afterwards kept for twenty-four hours in water, nearly at the boiling point. The cartilage, from which the earthy matter has been removed, is thus dissolved, and numberless minute vessels may be seen issuing from the undecomposed portion of bone, presenting a beautiful white velvety appearance, which is injured by the least motion. If the bone when immersed in dilute hydrochloric acid is exposed to heat, the chemical action is facilitated, and the bone develops carbonic acid and separates into fibrous lamellæ, divisible in a longitudinal direction, which, if they are sufficiently thin, possess the property of polarizing light in the same manner as mica.

When bone is submitted to thorough incineration, all the organic portion is destroyed, and there remains nothing but the earthy matter mixed with certain salts which have been formed during the process of incineration, such as alkaline sulphates and carbonates, and with free lime formed by the expulsion of the carbonic acid from carbonate of lime.

The carbonate of lime in bone is just the same as the natural carbonate of lime; the phosphate, on the other hand, consists of $8\,CaO + 3\,PO_5$, according to Berzelius[1]; and $3\,CaO + PO_5$, according to Mitscherlich. In addition to these salts we find small quantities of phosphate of magnesia and fluoride of calcium,[2] and traces of the peroxides of iron and manganese.

[An elaborate treatise on the Chemistry of Bone has been recently published by Von Bibra. We extract the following analyses:—

[1] [Berzelius repeated the analysis of the salt last year, and found that its composition is rightly expressed. (Oefversigt af Kongl. Vat. Akad. Förhandlingar, 1844, No. 6; or Liebig's und Wöhler's Annalen, Feb. 1845.]

[2] [The presence of fluoride of calcium in bone has been denied by Rees (Phil. Mag. Jan. 1840.) The researches of Daubeny and Middleton (Memoirs and Proceedings of the Chemical Society of London, vol. 2, pp. 97 and 134) not only demonstrate its almost constant occurrence both in recent and fossil bones, but point out that ordinary water is the vehicle by which it is conveyed into the system. "With regard to the statements of Rees," observes Von Bibra, "I put them to the proof, and found, as was to be expected, that they were altogether incorrect. I used in these experiments the human femur, humerus, and teeth. On treating large quantities of bone-earth with sulphuric acid, I have obtained corrosions on glass sufficiently deep to be felt with the finger-nail." (Chemische Untersuchungen über die Knochen und Zähne, p. 103, Schweinfurt, 1844.)]

	Male Fœtus at the 6—7th month.		
	Femur.	Tibia.	Humerus.
Phosphate of lime with barely recognizable traces of fluoride of calcium	53·46	53·46	53·15
Earthy carbonates	3·06	3·10	3·05
Phosphate of magnesia	2·10	2·00	1·96
Salts[1]	1·00	1·07	1·02
Cartilage	40·38	40·37	40·82
Fat	a trace	a trace	a trace
	100·00	100·00	100·00

	Female Fœtus at the 7th month.			
	Ulna.	Radius.	Scapula.	Clavicula.
Phosphate of lime with very little fluoride of calcium	57·63	57·67	57·13	56·95
Carbonate of lime	5·86	5·89	5·99	5·75
Phosphate of magnesia	1·10	0·99	1·12	1·07
Salts	0·60	0·67	0·62	0·73
Cartilage	34·78	34·08	34·32	34·54
Fat	0·63	0·50	0·82	0·96

	Child aged 2 months.	
	Tibia.	Ulna.
Phosphate of lime with a little fluoride of calcium	57·54	56·35
Carbonate of lime	6·02	6·07
Phosphate of magnesia	1·03	1·00
Salts	0·73	1·65
Cartilage	33·86	34·92
Fat	0·82	1·01

	Child aged 9 months.						
	Femur.	Humerus.	Tibia.	Radius.	Ulna.	Costa.	Scapula.
Phosphate of lime with a little fluoride of calcium	48·11	50·15	48·55	45·38	48·06	42·32	42·61
Carbonate of lime	6·12	6·13	5·79	5·14	6·20	5·00	5·08
Phosphate of magnesia	0·97	1·00	1·00	0·93	1·01	0·89	0·92
Salts	1·23	1·30	1·24	1·07	1·24	1·09	1·10
Cartilage	41·71	39·53	41·50	45·65	41·70	48·55	48·36
Fat	1·86	1·89	1·92	1·83	1·79	2·15	1·93

[1] The "salts" in the analyses of Von Bibra are the salts soluble in water.

	A child aged 5 years.		A girl[1] aged 19 years.	
	Femur.	Tibia.	Femur.	Humerus.
Phosphate of lime with a little fluoride of calcium	59·96	59·74	54·78	54·84
Carbonate of lime	5·91	6·00	10·90	10·82
Phosphate of magnesia	1·24	1·34	1·34	1·26
Salts	0·69	0·63	0·83	0·79
Cartilage	31·28	31·34	31·15	31·37
Fat	0·92	0·95	1·00	0·92

A woman aged 25 years.

	Femur.	Tibia.	Fibula.	Humerus.	Ulna.	Radius.	Metacarpus.
Phosphate of lime with a little fluoride of calcium	57·42	57·18	57·39	58·03	57·52	57·38	57·77
Carbonate of lime	8·92	8·93	8·92	9·04	8·97	8·95	8·92
Phosphate of magnesia	1·70	1·70	1·63	1·59	1·71	1·72	1·58
Salts	0·60	0·61	0·60	0·59	0·67	0·63	0·61
Cartilage	29·54	29·58	29·49	29·66	29·14	29·43	29·23
Fat	1·82	2·00	1·97	1·09	1·99	1·89	1·89

	Clavicula.	Os occipitis.	Costa.	Sternum.	Scapula.	Vertebræ.	Os innominatum.
Phosphate of lime with a little fluoride of calcium	56·35	57·66	52·91	42·63	54·76	44·28	49·72
Carbonate of lime	8·88	8·75	8·66	7·19	8·58	8·00	8·08
Phosphate of magnesia	1·69	1·69	1·40	1·11	1·53	1·44	1·57
Salts	0·59	0·63	0·60	0·50	0·51	0·53	0·60
Cartilage	30·66	29·87	33·06	46·57	32·90	43·44	38·26
Fat	1·83	1·40	2·37	2·00	1·73	2·31	1·77

A man 25 or 30 years of age.

	Femur.	Tibia.	Humerus.	Ulna.	Os occipitis.	Costa.
Phosphate of lime with a little fluoride of calcium	59·63	58·95	59·87	59·30	58·43	55·66
Carbonate of lime	7·33	7·08	7·76	7·35	8·00	6·64
Phosphate of magnesia	1·32	1·30	1·09	1·35	1·40	1·07
Salts	0·69	0·70	0·72	0·73	0·90	0·62
Cartilage	29·70	30·42	29·28	29·98	29·92	33·97
Fat	1·33	1·55	1·28	1·29	1·35	2·04

[1] This girl died from phlebitis thirteen days after the operation of amputation of the upper arm for caries of the elbow-joint.

	Femur of a man aged 58 years. Compact substance.	Spongy substance.
Phosphate of lime with fluoride of calcium	58·23	42·82
Carbonate of lime	8·35	19·37
Phosphate of magnesia	1·03	1·00
Salts	0·92	0·99
Cartilage	31·47	35·82

	Femur of a woman[1] aged 62 years.	Femur of a woman aged 78 years.
Phosphate of lime with a little fluoride of calcium	63·17	57·36
Carbonate of lime	4·46	7·48
Phosphate of magnesia	1·29	1·10
Salts	0·90	0·97
Cartilage	28·03	32·16
Fat	2·15	0·93

These are the most recent, and probably the most accurate of any of the analyses of human bone yet published. We may omit, from absolute superfluity of matter, the researches of Schreyer, Rees, Thilenius, Sebastian, Davy, Frerichs, and Stark, which refer merely to the estimation of the organic and inorganic matters, and shall take a brief survey of the more perfect analyses of bone.

Berzelius found in human bone:

Phosphate of lime	51·04
Fluoride of calcium	2·00
Carbonate of lime	11·30
Phosphate of magnesia	1·16
Soda, with a little chloride of sodium	1·20
Cartilage	32·17
Vessels	1·13

Dr. Thomson found[2] in the human femur:

	1.	2.
Phosphate of lime	43·67	51·12
Carbonate of lime	14·00	9·77
Magnesia	0·49	0·63
Soda	2·00	0·59
Potash	0·06	a trace
Cartilage	39·12	35·93

[1] A cretin. The bones had been underground for four years.

[2] Animal Chemistry, p. 245.

The four following analyses were made by Valentin:—1 represents the cortical portion of the tibia of a man aged 38 years; and 2, the medullary portion of the same bone; 3 represents the external condyle of the left femur of a girl; and 4, the head of the left tibia of the same individual.

	1.	2.	3.	4.
Basic phosphate of lime	52·930	49·019	37·012	41·774
Carbonate of lime	7·666	7·760	5·038	7·109
Phosphate of magnesia	0·254	1·542	0·874	0·874
Chloride of sodium	0·911	0·441	0·645	1·677
Carbonate of soda	0·204	0·076	1·331	
Cartilage, vessels, &c.	38·020	41·160	55·180	48·560

Marchand found in the compact substance of the femur of a man aged 30 years:

Basic phosphate of lime	52·26
Fluoride of calcium	1·00
Carbonate of lime	10·21
Phosphate of magnesia	1·05
Soda	0·92
Chloride of sodium	0·25
Cartilage insoluble in hydrochloric acid	27·23
Cartilage soluble in hydrochloric acid	5·02
Vessels	1·01
Peroxides of iron and manganese, and loss	1·05

The most recent analyses of human bones, with the exception of those by Von Bibra, are those of Lehmann.

	Bones of a man aged 40 years who committed suicide.					
	Humerus.	Radius.	Ulna.	Femur.	Fibula.	Tibia.
Phosphate of lime and fluoride of calcium	56·61	53·25	53·98	58·93	52·99	53·12
Carbonate of lime	9·20	9·76	9·51	9·28	9·33	9·35
Phosphate of magnesia	1·08	1·06	1·07	1·09	1·06	1·07
Chloride of sodium	0·37	0·36	0·40	0·40	0·37	0·39
Soda	1·35	1·36	0·98	1·04	1·07	0·99
Organic matter	31·52	33·76	33·23	28·61	34·14	34·10

From the bones of a man aged 44 years he obtained:

	Femur.	Tibia.	Fibula.
Phosphate of lime and fluoride of calcium	52·67	52·93	52·04
Carbonate of lime	10·03	9·88	10·13
Phosphate of magnesia	0·93	0·91	0·89
Soda	1·07	1·09	1·12
Chloride of sodium	0·34	0·31	0·39
Organic matter	34·15	33·94	34·51]

BONES OF THE LOWER ANIMALS.[1]

Mammalia.

[Edentata. Common armadillo.

	Bony plates from the region of the throat.	the abdomen.	the tail.
Phosphate of lime with a little fluoride of calcium	53·45	50·92	55·43
Carbonate of lime	6·73	6·63	6·99
Phosphate of magnesia	1·30	1·23	1·07
Salts	0·89	0·95	0·92
Cartilage	34·63	36·77	32·81
Fat	3·00	3·50	2·78

Glires.

	Squirrel (old).		Mouse.	Rat.	Hare.
	Femur.	Humerus.	Femur and tibia together.	Femur.	Femur.
Phosphate of lime with a little fluoride of calcium	57·03	55·27	50·31	60·38	58·45
Carbonate of lime	10·45	10·50	9·62	6·72	9·07
Phosphate of magnesia	1·36	1·32	1·10	1·91	0·99
Salts	0·90	0·91	0·83	0·91	0·82
Cartilage	29·46	31·21	36·84	28·98	29·60
Fat	0·80	0·79	1·30	1·10	1·07

Ruminantia.

	Sheep aged 4 years.	He-goat.	Bull aged 4 years.		
	Femur.	Os occip.	Femur.	Tibia.	Os occip.
Phosphate of lime with a little fluoride of calcium	55·94	47·07	54·07	54·03	52·51
Carbonate of lime	12·18	9·09	12·71	11·99	11·14
Phosphate of magnesia	1·00	1·59	1·42	1·44	1·05
Salts	0·50	1·02	0·80	0·70	0·50
Cartilage	29·68	39·58	29·09	29·92	32·80
Fat	0·70	1·65	1·91	1·92	2·00

[1] The whole of these analyses, with two exceptions, were made by Von Bibra.

PACHYDERMATA.

	Horse[1] (fœtus of about 3 months.)	Castrated horse aged 6 years.		Mare aged 14 years.
	Humerus and tibia.	Femur.	Humerus.	Femur.
Phosphate of lime with a little fluoride of calcium	60·51	54·37	52·86	54·63
Carbonate of lime .	1·83	12·00	12·07	11·28
Phosphate of magnesia .	1·40	1·83	1·75	1·50
Salts . .	a trace	0·70	0·71	0·40
Cartilage . .	36·26	27·99	29·70	27·98
Fat .	—	3·11	2·91	4·21

	Costa.[2]	Metatarsus.[2]	Wild-boar. Femur.
Phosphate of lime with a little fluoride of calcium	42·21	54·29	58·88
Carbonate of lime .	6·32	9·05	9·02
Phosphate of magnesia .	1·94	·69	1·17
Salts . .	1·22	1·78	0·92
Cartilage, Fat . .	47·30	34·16	28·00, 2·01

	CETACEA. Dolphin.		PINNIPEDIA. Common seal.	
	Costa.	Vertebræ.	Os occipitis.	Maxilla inf.
Phosphate of lime with a little fluoride of calcium	53·59	52·51	58·77	54·11
Carbonate of lime .	9·99	9·37	7·23	7·20
Phosphate of magnesia .	1·10	0·98	1·18	0·93
Salts . .	3·24	1·24	1·43	1·22
Cartilage . .	30·46	33·97	30·11	35·24
Fat . .	—	—	1·28	1·30

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[1] Von Bibra likewise analysed separately the compact and spongy substance of the femur of a horse aged 12 years, and obtained the following results:

	Compact substance.	Spongy substance.
Phosphate of lime with a little fluoride of calcium	54·65	41·14
Carbonate of lime . . .	11·74	18·93
Phosphate of magnesia . . .	1·48	1·32
Salts	0·86	0·94
Cartilage	31·27	37·67

[2] These analyses were made by Valentin.

FALCULATA.

	Cat aged 6 years.			Wolf.			
	Humerus.	Verteb.	Os occip.	Femur.	Humerus.	Costa.	Verteb.
Phosphate of lime with a little fluoride of calcium	59·30	48·01	51·70	57·87	55·36	51·76	48·72
Carbonate of lime	10·69	8·44	10·13	11·09	11·76	10·90	10·03
Phosphate of magnesia	1·70	0·97	1·07	1·13	1·07	1·00	0·88
Salts	0·40	0·39	0·37	1·02	0·99	0·90	0·91
Cartilage	27·21	40·79	35·83	27·44	29·51	33·78	37·53
Fat	0·70	1·40	0·90	1·45	1·31	1·66	1·93

VOLITANTIA.

	Common bat.	
	Femur.	Humerus.
Phosphate of lime with a little fluoride of calcium	57·45	56·90
Carbonate of lime	4·77	6·00
Phosphate of magnesia	1·03	1·00
Salts	0·75	0·80
Cartilage	34·20	34·27
Fat	1·80	1·03

POLLICATA.

	Cebus Capucinus (Capuchin ape).					
	Femur.	Humerus.	Vertebræ.	Costa.	Scapula.	Os ilii.
Phosphate of lime with a little fluoride of calcium	54·33	51·87	50·43	51·54	50·24	46·63
Carbonate of lime	7·99	7·33	6·92	7·00	7·31	6·03
Phosphate of magnesia	1·58	1·72	1·33	1·15	1·20	1·07
Salts	0·89	0·93	0·92	0·87	0·91	0·90
Cartilage	34·01	37·18	39·04	38·37	39·33	44·16
Fat	1·20	0·97	1·36	1·07	1·01	1·21

BIRDS.

	Thrush.		Sparrow 6 days old.	Sparrow (aged).	
	Femur.	Humerus.	Femur, tibia, & humerus together.	Femur.	Humerus.
Phosphate of lime with a little fluoride of calcium	58·64	62·65	39·78	59·46	60·04
Carbonate of lime	5·07	6·05	3·62	8·88	9·97
Phosphate of magnesia	0·83	0·90	0·40	1·03	1·09
Salts	0·77	0·84	0·30	0·90	0·90
Cartilage	33·43	28·02	55·80	27·20	26·14
Fat	1·26	1·54	0·10	2·53	1·86

REPTILES.

	Salamandra terrestris. Mixed bones.	Rana esculenta. Femur.	Rana esculenta. Tibia.	Coluber natrix. Vertebræ.	Anguis fragilis. Vertebræ.
Phosphate of lime with a little fluoride of calcium	53·89	59·48	59·73	59·41	47·52
Carbonate of lime	2·46	2·25	2·24	7·82	6·92
Phosphate of magnesia	1·07	0·99	0·97	1·00	1·11
Salts of soda	0·82	1·78	1·90	0·73	0·90
Cartilage	38·64	30·19	29·16	24·93	36·18
Fat	3·12	5·31	6·00	6·11	7·37

FISHES.

	Eel. Vertebræ.	Pike. Vertebræ.	Salmon. Vertebræ.	Cod. Vertebræ.	Cod. Os occip.
Phosphate of lime with a little fluoride of calcium	32·46	38·70	36·64	57·65	61·15
Carbonate of lime	3·64	14·30	1·01	4·81	5·20
Sulphate of lime	1·09				
Phosphate of magnesia	0·78	0·81	0·70	2·30	2·62
Sulphate of soda	0·83	0·97	0·83	1·00	1·03
Carbonate of soda & chloride of sodium	0·66				
Cartilage	36·99	32·72	21·80	31·90	27·89
Fat	23·55	12·50	38·82	2·34	2·11

We have selected these individual cases from 143 analyses of the bones of mammalia (independently of man); 151 of birds, 31 of reptiles, and 23 of fishes.]

Morbid Bones.

[*Rachitis.* The bones in this disease have been analysed by several chemists.

Lehmann examined the tibiæ of three rachitic children. He found:

	1.	2.	3.
Phosphate of lime	32·04	26·94	28·13
Carbonate of lime	4·01	4·88	3·75
Phosphate of magnesia	0·98	0·81	0·87
Chloride of sodium	0·21	0·27	0·28
Soda	0·54	0·81	0·73
Cartilage	54·14	60·14	58·77
Fat	5·84	6·22	6·94

Ragsky found in the scapula and humerus of a rachitic child:

Phosphates of lime and magnesia	15·60
Carbonate of lime	2·66
Soluble salts	0·62
Cartilage, vessels, and fat	81·12

In the ulna of a child aged 5—6 years, Von Bibra found:

Phosphate of lime with a little fluoride of calcium	47·83
Carbonate of lime	7·42
Phosphate of magnesia	1·23
Salts	1·82
Cartilage	35·61
Fat	6·09

Osteomalacia. Several analyses of bone in this disease are on record.

	Vertebra. (Bostock).	Vertebra. (Prösch.)	Costa. (Prösch.)
Phosphate of lime	13·60	13·25	33·66
Phosphate of magnesia	0·82	—	—
Carbonate of lime	1·13	5·95	4·60
Sulphate of lime and phosphate of soda	4·70	0·90	0·40
Cartilage	79·75	74·64	49·77
Fat	—	5·26	11·63

An analysis by Bogner of the bones of a man aged 32 years, who died from osteomalacia, yielded the following results:

	Scapula.	Radius.	Femur.	Patella.
Phosphate of lime	26·92	28·11	23·50	23·23
Carbonate of lime	0·98	1·07	0·97	0·94
Phosphate of magnesia	5·40	6·35	5·07	5·03
Cartilage and vessels	65·85	63·42	69·77	70·60
Soda, iron, and loss	0·85	1·05	0·69	0·64

Ragsky has analysed bone in this disease. He found in a rib:

Phosphates of lime and magnesia	17·48
Carbonate of lime and salts	6·32
Cartilage, vessels, and fat	76·20

After the removal of the fat, Lehmann found:

	1.	2.	3.
Phosphate of lime	36·863	31·718	35·871
Other salts	4·968	7·913	5·684
Cartilage	58·169	60·369	58·445

and in two other cases of osteomalacia occurring in persons aged about 40 years, the same chemist found:

	1.		2.	
	Femur.	Costa.	Femur.	Costa.
Phosphate of lime	17·56	21·02	18·83	19·14
Carbonate of lime	3·04	3·27	3·83	4·08
Phosphate of magnesia	0·23	0·44	0·54	0·60
Soluble salts	0·37	0·63	0·43	0·41
Cartilage	48·83	50·48	41·54	42·43
Fat	29·18	23·13	34·15	32·65

The three following analyses of bone in this disease were made by Von Bibra:

	Tibia of a woman aged 75 years.	Femur of a woman 83 years.	Femur of a man aged 60 years.
Phosphate of lime with a little fluoride of calcium	55·01	46·79	53·25
Carbonate of lime	4·94	6·37	7·49
Phosphate of magnesia	2·01	1·20	1·22
Salts	0·31	1·37	1·35
Cartilage	29·17	30·99	32·54
Fat	8·56	13·28	4·15

Marchand found the bones of the child whose case is noticed in p. 286 of this Volume, composed in the following manner:

	Vertebra.	Radius.	Femur.	Sternum.
Phosphate of lime	12·56	15·11	14·78	21·35
Phosphate of magnesia	0·92	0·78	0·80	0·72
Carbonate of lime	3·20	3·15	3·00	3·70
Sulphate of lime, Sulphate of soda	0·98	1·00	1·02	1·68
Fluoride of calcium, chloride of sodium, iron, and loss	1·00	1·20	1·00	2·01
Cartilage	75·22	71·26	72·00	61·20
Fat	6·12	7·50	7·20	9·34

The cartilage yielded neither glutin nor chondrin.

Arthritis. Marchand analysed the upper part of the femur, and the bones of the fore-arm of a person with abundant tophaceous deposits in the knee- and elbow-joints. He found in these bones:

	Femur.	Radius & ulna.
Phosphate of lime . . .	42·12	43·18
Carbonate of lime . . .	8·24	8·50
Phosphate of magnesia . . .	1·01	0·99
Animal matter . . .	46·32	45·96
Fluoride of calcium, soda, chloride of sodium, and loss	2·31	1·37

Lehmann analysed the bones of three persons with chronic gout; their ages varied from 40 to 50 years. He found:

	1.	2.	3.
Phosphate of lime . .	35·16	35·83	37·22
Carbonate of lime . .	8·41	9·82	8·99
Phosphate of magnesia .	1·31	1·05	1·13
Soluble salts . .	2·93	2·03	1·82
Cartilage . . .	38·14	38·26	40·03
Fat . . .	12·11	13·37	9·15

Caries. Valentin has analysed carious bones, and likewise an osteophyte incrustation surrounding the carious tibia of a man aged 38 years.

	Tibia of a man aged 38 years.	Vertebra of a man aged 20 years.
Phosphate of lime . .	34·383	33·914
Carbonate of lime . .	6·636	7·602
Phosphate of magnesia .	1·182	0·389
Chloride of sodium, Carbonate of soda . .	1·919	3·157 0·118
Organic constituents . .	55·880	54·830

	External condyle of the femur of a girl.	Head of tibia of the same individual.
Phosphate of lime .	39·393	45·451
Carbonate of lime .	4·620	5·683
Phosphate of magnesia .	0·520	1·180
Chloride of sodium .	0·424	1·620
Carbonate of soda .	0·647	0·446
Organic constituents .	54·396	45·620

In the osteophyte incrustation there were contained:

Phosphate of lime	29·424
Carbonate of lime	4·201
Phosphate of magnesia	0·317
Chloride of sodium	5·556
Carbonate of soda	1·117
Organic matters	59·370

Von Bibra has also made several analyses of carious bones.

	Bones of the hand of a man.		
	Metacarpal bone.	Its upper articulating portion.	Phalanx.
Phosphate of lime with a little fluoride of calcium	49·77	31·36	49·36
Carbonate of lime	7·24	4·07	8·08
Phosphate of magnesia	1·11	0·83	0·98
Salts	0·30	0·30	0·40
Cartilage	37·97	59·36	37·47
Fat	3·61	4·08	3·71

	Femur of a man.	
	Diseased portion.	Mass of the bone.
Phosphate of lime with a little fluoride of calcium	51·53	54·98
Carbonate of lime	5·44	5·97
Phosphate of magnesia	3·43	3·70
Salts	0·91	0·89
Cartilage	35·69	31·44
Fat	3·00	3·02

	Palate bone of a woman aged 40 years, with inveterate syphilis. (The portion submitted to analysis was thrown off during her lifetime, and weighed 16·5 grains.)
Phosphate of lime with fluoride of calcium	45·14
Carbonate of lime	5·03
Phosphate of magnesia	2·40
Salts	0·82
Cartilage	42·34
Fat	4·27

	Tibia of a man aged 25 years.	Tarsus of a man aged 40-50 years.
Phosphate of lime with fluoride of calcium	47·79	39·22
Carbonate of lime	6·44	6·87
Phosphate of magnesia	1·30	0·50
Salts	2·00	2·10
Cartilage	28·57	29·23
Fat	13·60	22·09

	Nasal bone of a girl aged 15 years.	Lumbar vertebra[1] of a woman aged 40 years.
Phosphate of lime, with fluoride of calcium .	45·77	44·05
Carbonate of lime .	3·77	3·45
Phosphate of magnesia	1·45	1·02
Salts . .	1·10	1·70
Cartilage . .	38·62	41·42
Fat . .	9·29	8·36

Necrosis. The following analysis was made by Von Bibra:

	Phalanx of a man aged 40-50 years.
Phosphate of lime, with fluoride of calcium .	72·63
Carbonate of lime	4·03
Phosphate of magnesia . . .	1·93
Salts	0·61
Cartilage	19·58
Fat	1·22

This small amount of organic matter is not characteristic of necrotic bone, for in two minute portions thrown off after fractures Von Bibra found:

	1.	2.
Organic matter . .	37·87	31·58
Inorganic matter . .	60·77	67·33
Fat . . .	1·36	1·09

Osteoporosis. Ragsky has analysed a specimen of osteoporosis growing on the cranium of an aged person. It yielded gelatin when boiled. It contained:

Phosphates of lime and magnesia .	55·80
Carbonate of lime and salts . .	5·59
Cartilage, vessels, and fat . .	38·61

[1] In the cavity of this bone, produced by the caries, there was a thick, reddish yellow matter, like inspissated pus. It consisted of 81·3 parts of water and volatile matter, and 18·7 of solid constituents. The latter contained in 100 parts:

Albuminous matter .	19·7
Alcohol-extract and lactates .	0·9
Water-extract . .	2·4
Shreds of cartilage .	51·0
Fat . . .	7·2
Fixed salts . .	18·8 containing 90% of phosphate of lime.

Sclerosis. Ragsky has analysed bone in several cases of this affection.

	Simple sclerosis of the cranium of a madman.
Phosphate of lime with fluoride of calcium	54·10
Carbonate of lime	10·45
Phosphate of magnesia	1·00
Soluble salts	1·04
Cartilage and vessels	33·41

	Sclerosis consecutive on osteoporosis. (The bone not specified.)
Phosphates of lime and magnesia	48·20
Carbonate of lime	7·45
Soluble salts	0·25
Cartilage, fat, and vessels	44·10

	Sclerosis more highly developed.
Phosphates of lime and magnesia	50·29
Carbonate of lime and soluble salts	7·20
Cartilage and vessels	42·51

	Sclerosis in the highest degree.
Phosphates of lime and magnesia	55·52
Carbonate of lime	5·95
Soluble salts	0·26
Cartilage and vessels	38·27

	Sclerosis of the femur.
Phosphates of lime and magnesia	53·21
Carbonate of lime	8·30
Cartilage and vessels	38·49

	Syphilitic sclerosis, highly developed.
Phosphates of lime and magnesia	57·20
Carbonate of lime	6·50
Cartilage and vessels	36·30

Exostosis. Lassaigne has analysed an exostosis, the thickened bone to which it was attached, and a healthy portion of the same bone.

	Thickened bone.	Healthy bone.	Exostosis.
Phosphate of lime	36·3	41·6	30·0
Carbonate of lime	6·5	8·2	14·0
Soluble salts	14·2	8·6	10·0
Organic matter	43·0	41·6	46·0

Von Bibra has analysed an exostosis on the humerus of a

dog. In the second analysis the composition of the healthy radius and ulna are represented.

	1. Exostosis.	2. Radius and ulna.
Phosphate of lime with fluoride of calcium	47·99	60·95
Carbonate of lime	1·00	2·84
Phosphate of magnesia	1·55	1·39
Salts	0·91	0·93
Cartilage	45·74	32·88
Fat	2·81	1·01

We observe in both these cases that the exostosis contains a larger amount of organic matter than healthy bone.]

I have analysed a remarkable osteoid tumour that formed on the knee of a leucophlegmatic boy aged 14 years, who was suffering from œdema. The tumour was ten inches long and twenty-five broad, and could be hardly half spanned with both hands. The limb was amputated and the tumour examined. I analysed separately three portions of the tumour, one hard and bony, a second softer, and a third perfectly soft. On exposing them to heat on an oil-bath, the first became white and earthy, while the other portions assumed a horny appearance.

Ether took up a dirty yellow, non-phosphorized fat.

The three specimens yielded on analysis:

	Anal. 155.	Anal. 156.	Anal. 157.
Phosphate of lime	35·85	8·00	9·20
Carbonate of lime	2·70	0·62	0·64
Phosphate of magnesia	0·58	0·21	—
Soluble salts	0·52	0·39	0·72
Chloride of sodium	0·26		
Fat	1·16	3·61	3·21
Cartilage and vessels	58·91	87·04	86·20

The proportions of the fixed salts to each other in these cases, and as they occur in normal bone, are exhibited in the following table:

	1.	2.	3.	Healthy bone.
Phosphate of lime	89·7	86·5	86·9	79·4
Phosphate of magnesia	1·5	1·9	—	1·7
Carbonate of lime	6·8	6·6	6·0	16·9
Soluble salts	0·7	4·1	6·8	1·4
Chloride of sodium	1·3			0·4

The most striking peculiarity is the relative diminution of the carbonate of lime.

[*Callus* has been analysed by Lassaigne and Von Bibra. Lassaigne examined the outer and inner portions of a mass of callus. He found:

	External portion.	Internal portion.
Phosphate of lime . . .	33·3	32·5
Carbonate of lime . . .	5·7	6·2
Soluble salts . . .	11·3	12·8
Animal matter . . .	50·0	48·5

The following analyses were made by Von Bibra:

	Callus from the tibia of a hare.	Callus from the rib of a horse.
Phosphate of lime with fluoride of calcium . . .	32·62	43·90
Carbonate of lime . .	1·01	5·69
Phosphate of magnesia . .	1·13	1·20
Salts . . .	1·79	0·74
Cartilage . . .	61·41	46·97
Fat . . .	2·04	1·50

Hence callus does not contain so large an amount of earthy salts as true bone.]

The Teeth.

The teeth, like the bones, consist of phosphate and carbonate of lime, fluoride of calcium and cartilage. The bony matter of the tooth is covered superiorly with enamel, while the fangs are coated with cement or cortical matter, which likewise overlays the enamel of the crown. Of the three constituents of tooth, enamel, bone (dentine), and cortical substance, the last is the poorest in inorganic matter. Lassaigne found therein:

Organic matter . . .	42·18
Phosphate of lime . . .	53·84
Carbonate of lime . . .	3·98

The osseous portion (dentine) hardly differs from true bone. Berzelius found therein:

Cartilage and vessels . . .	28·0
Phosphate of lime with fluoride of calcium .	64·3
Carbonate of lime . . .	5·3
Phosphate of magnesia . . .	1·0
Soda, with chloride of sodium . .	1·1

Pepys found:

Cartilage	28·0
Phosphate of lime . . .	58·0
Carbonate of lime . . .	4·0
Water and loss . . .	10·0

From analyses made by Lassaigne of human teeth at different ages, it appears that the phosphate of lime gradually increases, and that there is a corresponding diminution of the carbonate.

	Organic matter.	Phosphate of lime.	Carbonate of lime.
Tooth of a child one day old . .	35·00	51·00	14·00
„ of a child aged 6 years . .	28·57	60·01	11·42
„ of an adult man . .	29·00	61·00	10·00
„ of a man aged 81 years . .	33·00	66·00	1·00

In the enamel of human teeth, Berzelius found:

Phosphate of lime with fluoride of calcium .	88·5
Carbonate of lime . . .	8·0
Phosphate of magnesia . . .	1·5
Membrane, alkali, and water . .	2·0

So that this substance seems almost destitute of organic combination.

[Von Bibra has made the following analyses of human teeth:

	Molar tooth of a woman aged 25 years.		Molar tooth of an adult male.	
	Enamel.	Osseous portion.	Enamel.	Osseous portion.
Phosphate of lime with a little fluoride of calcium	81·63	67·54	89·82	66·72
Carbonate of lime .	8·88	7·97	4·37	3·36
Phosphate of magnesia .	2·55	2·49	1·34	1·08
Salts . .	0·97	1·00	0·88	0·83
Cartilage . .	5·97	20·42	3·39	27·61
Fat . .	a trace	0·58	0·20	0·40

For a series of analyses of the teeth of the lower animals I must refer the reader to the original work, (Chemische Untersuchungen über die Knochen und Zähne des Menschen und der Wirbelthiere,) which may be regarded as a perfect monograph on the subject of which it treats.]

Cartilage.

The cartilages are invested with a peculiar membrane, the perichondrium; they are not so hard as bone, but are more elastic and supple. They are usually divided into two classes, the true and the fibrous cartilages. In addition to their respective microscopic appearances, they present well-marked chemical differences. The true cartilages dissolve almost entirely in water, and yield chondrin (see Introduction, p. 25). If, however, the boiling is interrupted before the solution is perfectly effected, it will be found that the cells have remained almost unchanged, and that only the basic substance has been dissolved. Even when true cartilage is perfectly dissolved the solution is somewhat turbid, owing, probably, to a partial change in the cells. Fibrous cartilage, in which the cells form the preponderating mass when continuously boiled for forty-eight hours, yields only a small quantity of extract, which exhibits all the ordinary reactions of chondrin, but does not gelatinize. The inorganic constituents of cartilage form only a small portion of their mass; Fromherz and Gugert[1] found in the costal cartilage of a man aged 20 years, 3·402% of fixed salts, associated in the following proportions:

Carbonate of soda	35·1
Sulphate of soda	24·2
Chloride of sodium	8·2
Phosphate of soda	0·9
Sulphate of potash	1·2
Carbonate of lime	18·3
Phosphate of lime	4·1
Phosphate of magnesia	6·9
Peroxide of iron and loss	0·9

In the corresponding cartilage of a woman aged 63 years, the same salts were observed, but to a smaller amount: there was also a larger amount of phosphate than of carbonate of lime.

[The following analyses of cartilage are extracted from Von Bibra's work:—

[1] Schweiger's Journal, vol. 50, p. 187.

	Costal cartilage of a child aged 6 months.	Ditto of a child aged 3 years.
	100 parts yielded	
	2·24 of the following ash:	3·00 of the following ash:
Phosphate of lime . .	20·86	21·33
Sulphate of lime . .	50·68	48·68
Phosphate of magnesia . .	9·88	8·88
Sulphate of soda . .	9·21	10·93
Phosphate of soda } . .	a trace	3·00
Carbonate of soda }		—
Chloride of sodium . .	9·37	7·18

	Costal cartilage of a girl aged 19 years.	Ditto of a woman aged 25 years.	Ditto of a man aged 40 years.
		100 parts yielded	
	7·29 of the following ash:	3·92 of the following ash:	6·1 of the following ash:
Phosphate of lime .	5·36	6·33	13·09
Sulphate of lime .	92·41	87·32	79·03
Phosphate of magnesia	0·99	4·10	3·78
Sulphate of soda .	1·24	0·95	1·22
Phosphate of soda .	a trace	a trace	0·93
Chloride of sodium .	a trace	1·30	1·95
Carbonate of soda .	—	a trace	a trace
Carbonate of lime .	—	—	a trace]

Synovia.

The synovial fluid is viscid, transparent, of a yellow or reddish colour, faintly saline, and resembles in its odour the serum of the blood. A specimen of this fluid, analysed by John, contained:

Water	92·80
Albumen	6·40
Extractive matter, with muriate and carbonate of soda	0·60
Phosphate of lime	0·15

Cellular Tissue, Tendons, Ligaments, Skin, Hair.

These may be classified together as tissues that yield gelatin. They are distinguished more by their microscopical than their chemical characters, and we may refer to Henle for an excellent account of their minute structure. The elements of cellular or combining tissue (Bindegewebe) in whatever part of the body it occurs are long, fine, hyaline fibrillæ or cylinders, varying in diameter from ·0003 to ·0008 of a line, and lying in close ap-

position. They are firm and elastic, are not changed by cold water, nor dissolved by acetic acid; the latter reagent renders them gelatinous and tough, but takes up no protein-compound. The organs containing this tissue diminish when boiled, become harder and more rigid, but ultimately soften and dissolve into gelatin, forming a solution that stiffens on cooling. Alcohol, ether, and oil exert no action on cellular tissue, even when aided by heat.

Tendons swell on being boiled, become yellow, and are gradually converted into gelatin. The solution is turbid in consequence of the flocculent appearance presented by minute vessels in suspension. In concentrated acetic acid they swell, become transparent and gelatinous, and in this state readily dissolve in hot water, from which neither an alkali nor ferrocyanide of potassium throws down any precipitate.

Ligaments consist partly of cellular and partly of elastic tissue, and these two structures present both chemical and physiological differences. True elastic tissue is not changed by acetic acid, is not converted by boiling into gelatin, but with the aid of heat dissolves readily in dilute mineral acids, from which it is not precipitated by ferrocyanide of potassium. As illustrations of the true elastic tissue we may refer to the ligamenta flava between the vertebræ and the ligamentum nuchæ in the ruminants.

The *cutis*, or true skin, is a contractile cellular tissue convertible, by boiling, into gelatin. It is permeated by a fluid, and contains also cellular tissue and vessels. Wienholt has endeavoured to determine their relative proportions; he obtained:

Cutaneous tissue (including cellular tissue and vessels)	32·53
Water	57·50
in which were dissolved:	
Albumen	1·54
Alcohol-extract	0·83
Water-extract	7·60

The skins of different animals require boiling for different lengths of time in order to be converted into gelatin, and the change is effected more rapidly in young than in old animals.

The conversion of the cutis into gelatin is much facilitated by the action of dilute alkalies or acids; it then takes place at an ordinary temperature. The skin combines with basic sulphate of iron, and with bichloride of mercury, when immersed in

solutions of those salts, and it then resists putrefaction. It likewise combines with tannin, forming a substance insoluble in water, and no longer tending to putrefaction (leather).

The *epidermis* is affected by strong mineral acids: concentrated sulphuric acid dissolves it, as also do the caustic alkalies. Many metallic salts combine with and colour it. The terchloride of gold communicates a purple, nitrate of the protoxide of mercury a reddish brown, and nitrate of silver a black colour: the volatile oxide of chrome (?) exerts a similar effect, and even the alkaline sulphurets communicate a brown or black colour to it.

[The hair has recently been examined by Scherer and Van Laer.[1] By treating the hair with spirit, ether, and water, there were removed margarin and margaric acid, olein, a brown matter soluble in water, chlorides of sodium and potassium, and lactate of ammonia.

By ultimate analysis there were then obtained:

	Scherer.				Van Laer.	
	1.	2.	3.	4.	1.	2.
Carbon	51·529	50·652	50·622	49·935	50·12	50·65
Hydrogen	6·687	6·766	6·613	6·631	6·33	6·36
Oxygen }	23·848	24·643	24·829	25·498	21·03	20·81
Sulphur }					4·99	5·00
Nitrogen	17·963	17·963	17·963	17·963	17·52	17·14

No. 1 was hair of the beard; 2, of the head of a fair person; 3, was brown hair; and 4, black hair from a Mexican. The ash in 1 amounted to 0·72%; in 2, to 0·8%; and in 4, to 2·0%.

According to Van Laer, the inorganic constituents in 100 parts are:

Colour.	Ash.	Soluble portion.	Peroxide of iron.	Insoluble portion.
Brown hair	0·54	0·17	0·058	0·312
„	1·10	0·51	0·395	0·200
„	0·32	—	—	—
Black hair	1·02	0·29	0·214	0·516
„	1·15	—	—	—
Red hair	1·30	0·93	0·170	0·200
„	0·54	0·27	0·275	—
„	1·85	—	—	—
Gray hair	1·00	0·24	0·232	0·528
„	0·75	—	—	—

[1] Scheik. Onderzoeck, 2° St. p. 75.

The soluble portion consisted of chloride of sodium, sulphate of lime, and sulphate of magnesia; the insoluble constituents were phosphate of lime and silica.

From Van Laer's investigations it appears that the hair consists essentially of:

1. A connecting medium consisting of a tissue yielding gelatin and represented by the formula $C_{13}\ H_{10}\ N_3\ O_5$;—and
2. Of bisulphuret of protein, $C_{40}\ H_{31}\ N_5\ O_{12}\ S_2$.

The large amount of sulphur in hair (averaging 5%) is the cause of its colour being affected by various metallic salts. As there is no constant difference in the results obtained by the analysis of hair of various tints, it is to be presumed that the colour is dependent on peculiar arrangements of the ultimate particles.

Hair further contains about 0·4% of peroxide of iron, which is supposed by Van Laer to be chemically combined with the protein.]

Crystalline Lens and Fluids of the Eye.

The crystalline lens is insoluble in boiling water, spirit, and acids; it does not even communicate any turbidity to them; hence it consists neither of cellular nor elastic tissue, but is a distinct substance, approximating possibly towards horny tissue. The membrana Demoursii, the third layer of the cornea, possesses similar properties, while the true horny layer which lies between the external layer of epithelium and the membrana Demoursii appears to be fibrous, and is converted by boiling into chondrin. The crystalline lens itself possesses a peculiar and very regular fibrous arrangement. Chevenix found the specific gravity of the human lens to be 1079, and that of the sheep 1180. I have observed that the crystalline lens in young animals is softer, and less resisting than at a more advanced age.

With respect to the chemical composition of the lens, I find that, in addition to albumen, it contains a substance closely resembling casein, to which I apply the term crystallin. I reduce the lens to a pulpy mass, stir it with water, and then heat the mixture to the boiling point: the albumen coagulates, while the crystallin does not coagulate, but is entangled

in the albumen. In order to separate them I evaporate to dryness, pulverize the white residue, and boil it, first with ether in order to separate fat, and then with spirit of ·915 as long as anything continues to be taken up. The albumen rapidly sinks from the hot, clear, spirituous solution, and the supernatant fluid which must be decanted from the sediment, soon begins to become turbid from the separation of numerous flocculi of crystallin. I evaporate to a slight residue, and then precipitate the crystallin by strong alcohol, in which it is only slightly soluble. The lactates and chloride of sodium remain dissolved in the alcohol. In this manner I analysed the crystalline lens of the ox and the horse.

	Anal. 158. Crystalline lens of ox.	Anal. 159. Ditto of horse.
Water	65·762	60·000
Albumen	23·290	25·531
Crystallin	10·480	14·200
Fat	0·045	0·142
Extractive matter with chloride of sodium and lactates	0·495	0·426

Berzelius has not separated the albumen and crystallin; in other respects his analysis approximates to mine, as far as the amount of the protein-compounds is concerned.

He found it composed of:

Water	58·0
Protein-compounds	35·9
Alcohol-extract with salts	2·4
Water-extract with traces of salts	1·3
Cell-membrane	2·4

It has been shown by Wurzer and Lassaigne, that when the lens is opaque (in cases of cataract) it contains an excess of phosphate of lime. This may be the cause of the opacity, or it may be due to the coagulation of the protein-compounds by the presence of a free acid. Wurzer determined the composition of an opaque lens from a bear. It contained (after the removal of the water):

Phosphate of lime	68·9
Carbonate of lime	12·6
Carbonate of magnesia	3·6
Peroxides of iron and manganese	0·7
Mucus (?)	7·5
Phosphate of lime with an animal matter	2·1
Chloride of sodium with animal matter	3·2
Solid fat	1·1

Lassaigne analysed an opaque lens from a horse. It contained:

Coagulated albumen	29·3
Phosphate of lime	57·4
Carbonate of lime	1·6
Soluble salts and other matters	17·7

The vitreous humour is perfectly clear and contains a very small amount of solid constituents in solution. It is enclosed in numerous compartments by a very delicate transparent membrane. On removing it by gentle pressure from this membrane, and evaporating it to dryness, it yields only ·016% of a colourless residue consisting for the most part of chloride of sodium. Berzelius obtained from it:

Water	98·40
Albumen	0·16
Chloride of sodium with a little extractive matter	1·42
A substance soluble in water	0·02

The aqueous humour contains, according to Berzelius:

Water	98·10
Albumen	a mere trace
Chloride of sodium with a little alcohol-extract	1·15
Extractive matter soluble only in water	0·75

The Arteries and Veins.

Very little is known with certainty regarding the chemical composition of the different coats of the blood-vessels, but their microscopic characters have been thoroughly examined by Henle. Berzelius has shown that the middle coat of the arteries belongs to the elastic tissues; Eulenberg, on the other hand, asserts that from 30 grains of dried arterial membrane (middle coat) he obtained, by three successive boilings, occupying in all 120 hours, 11 grains of dried substance which dissolved in water and gelatinized on cooling. Valentin found that an acetic-acid solution of arterial membrane is precipitated by ferrocyanide of potassium, and I have obtained a solution of the middle coat (by boiling it in water for ten hours) which is strongly precipitable by acetic acid. The greater part of the precipitate dissolves in an excess of the acid, and is again thrown down by ferrocyanide of potas-

sium: tannin, bichloride of mercury, and basic acetate of lead cause considerable turbidity.

The Muscles.

Muscular fibre is chemically distinguished from the fibre of cellular tissue by the circumstance that it does not yield gelatin by prolonged boiling in water, but dissolves in acetic acid, from which it may be precipitated by ferrocyanide of potassium, showing that it belongs to the protein-compounds. The microscopic characters of the various species of muscular fibre have been well described by Henle.

In consequence of the difficulty that exists in separating muscular fibre from cellular tissue, vessels, and nerves, it is impossible to speak with certainty respecting the behaviour of pure muscle towards reagents. If very small pieces of muscle are freed as much as possible from fat and cellular substance, and immersed in water, blood, colouring matter, and the extractive matter with which muscle abounds, are gradually taken up, and colourless muscular fibres are left.

Cold water and alcohol produce little effect on them, but in boiling water they first contract and become firm, and subsequently soften. Concentrated acetic acid dissolves them; in the dilute acid they swell and assume a transparent fibrous appearance. The alkaline carbonates increase their firmness. Solutions of muscular fibre in dilute acids are precipitated by ferrocyanide of potassium and tannin in a precisely similar manner to acid solutions of fibrin. Dried muscular fibre may be easily pulverized; in that condition it resembles the whole class of protein-compounds in exhibiting strong positively electrical properties.

On making incisions into the warm flesh of an animal just killed, we obtain, by pressure, an acid fluid which rapidly coagulates in consequence of the presence of a little fibrin: if the flesh has been kept for some time the fluid obtained by pressure no longer coagulates, although it exhibits an acid reaction. No quantitative analysis of human flesh[1] has yet been

[1] [The following analyses of human flesh by Marchand (Lehrbuch der Physiologischen Chemie, p. 156) and L'Heretier (Traité de Chimie Pathologique, p. 660) have

made, but the flesh of several animals has recently been submitted to analysis. The amount of water averages about 80%, and the greater part of the solid residue consists of fibrin; the other constituents, albumen, hæmatoglobulin, fat, extractive matters, lactic acid, the lactates and other salts occur in the expressed juice. The proportions of these constituents have been determined by Berzelius, Braconnot, Schlossberger, Schultz, [and Marchand.] In the flesh of oxen they found:

	Berzelius.	Braconnot.	Schlossberger.	Schultz.	Marchand.
Water . . .	77·17	77·03	77·50	77·50	76·60
Fibrin, cells, vessels & nerves	17·70	18·18	17·50	15·00	18·00
Albumen & hæmatoglobulin	2·20	2·70	2·20	4·30	2·50
Alcohol-extract and salts .	1·80	1·94	1·50	1·32	1·70
Water-extract and salts .	1·05	1·15	1·30	1·80	1·10
Phosphate of lime with albumen	0·08	—	traces	—	0·10
Fat and loss . .	—	—	—	0·08	—

[The dried muscular flesh of the ox has been analysed by Playfair and Böckmann, and found to be identical in its composition with dried blood:

	Flesh (beef.)		Ox-blood.	
	Playfair.	Böckmann.	Playfair.	Böckmann.
Carbon .	51·83	51·89	51·95	51·96
Hydrogen .	7·57	7·59	7·17	7·33
Nitrogen .	15·01	15·05	15·07	15·08
Oxygen .	21·37	21·24	21·39	21·21
Ashes .	4·23	4·23	4·42	4·42

Deducting the ashes or inorganic matter, the composition of the organic part is:

Carbon .	54·12	54·18	54·19	54·20
Hydrogen .	7·89	7·93	7·48	7·65
Nitrogen .	15·67	15·71	15·72	15·73
Oxygen .	22·32	22·18	22·31	22·12

which corresponds to the formula $C_{48} H_{39} N_6 O_{15}$.

appeared since the publication of Simon's Chemistry. The flesh in the first analysis was taken from the upper portion of the arm of a man who died from diseased liver.

	Marchand.	L'Heretier.
Water and loss . . .	78·00	77·10
Matter insoluble in cold water .	17·00	15·80
Soluble albumen with colouring matter .	2·30	3·40
Alcohol-extract with salts . .	1·60	1·20
Water-extract with salts . .	1·00	2·50
Phosphate of lime, with albumen .	0·10	—]

In 100 parts of the ashes yielded by the incineration of ox-flesh Enderlin found:

Tribasic phosphate of soda ($3NaO, PO_5$)	45·100	91·036 soluble salts	
Chlorides of sodium and potassium	45·936		
Phosphates of lime, magnesia, and peroxide of iron		6·840 insoluble salts	
Loss		2·124	
		100·000]	

The following analyses of the flesh of other animals have been made by Schlossberger:

	Calf. 1.	Calf. 2.	Swine.	Roe.	Pigeon.	Chicken.	Carp.	Trout.
Water	79·7	78·2	78·3	76·9	76·0	77·3	80·1	80·5
Muscular fibre and vessels	15·0	16·2	16·8	18·0	17·0	16·5	12·0	11·1
Albumen and hæmatoglobulin	3·2	2·6	2·4	3·3	4·5	3·0	5·2	4·4
Alcohol-extract with salts	1·1	1·4	1·7	2·4	1·0	1·4	1·0	1·6
Water-extract with salts	1·0	1·6	0·8		1·5	1·2	1·7	0·2
Phosphate of lime with albumen	0·1	traces	traces	0·4	—	0·6	—	2·2

The analyses of Schultz correspond in many points with those of Schlossberger. In calves' flesh Schultz found a little more animal fibre than Schlossberger: in the flesh of a pig four weeks old Schultz found 21·1 parts of muscular fibre and 3·45 of albumen and hæmatoglobulin; and in the flesh of a pig two years and a half old he found 20·3 parts of the former and 4·2 of the latter. Schultz also found that the amount of muscular fibre was less in the flesh of fishes than in that of the mammalia: thus in the flesh of cyprinus nasus, and cyprinus barbus the proportions of fibre were 13·5 and 17·18 respectively.

[We may take this opportunity of noticing an interesting paper by Helmholtz,[1] on the consumption of tissue during muscular action.

Powerful muscular contractions were induced by passing an electric current through the amputated leg of a frog as long as convulsions continued to be manifested. The flesh of the two legs was then analysed. The albumen was apparently scarcely affected, the mean of 6 experiments giving 2·10% of albumen in the electrized, and 2·13% in the non-electrized flesh. With regard to the extractive matters it appeared that in all the experiments, without a single exception, the water-extract in the electrized flesh was diminished, while on the other hand the spirit- and alcohol-extracts were increased by that process. The results are expressed in the following tables.

[1] Müller's Archiv. 1845.

Alcohol-extract from 100 parts of recent frog's flesh.

Exp.	a. In electrised portion.	b. In non-electrised portion.	a : b
1	0·752	0·606	1·24 : 1
2	0·569	0·427	1·33 : 1
3	0·664	0·481	1·38 : 1
4	0·652	0·493	1·32 : 1
5	0·575	0·433	1·33 : 1
	Extracted with alcohol of 95 per cent.		
6	1·020	0·748	1·36 : 1

	Water-extract.			Spirit-extract.		
	a.	b.	a : b	a.	b.	a : b
7	1·21	1·63	0·79 : 1	1·69	1·50	1·13 : 1
8	0·93	1·23	0·76 : 1	1·65	1·35	1·22 : 1
9	0·72	0·90	0·80 : 1	1·76	1·53	1·15 : 1
Mean	0·95	1·25	0·78 : 1	1·70	1·46	1·16 : 1

The amount of fat was unaffected. No urea could be found in the alcohol-extract.

There is great difficulty in performing experiments of this nature on warm-blooded animals in consequence of the rapidity with which isolated portions of muscle lose their irritability.

The best results were obtained with decapitated pigeons.

	a. In electrised muscle.	b. In non-electrised muscle.	a : b
Albumen . .	2·04	2·13	—
Water-extract .	0·64	0·73	0·88 : 1
Spirit-extract .	1·68	1·58	1·06 : 1

It remains to be considered whether the fibrin takes part in this decomposition: *à priori* we should infer that it did, for the protein-compounds seem universally the conductors of the highest vital energies, and further the increased amount of sulphates and phosphates in the urine after muscular exertion indicates a decomposition of the sulphur and phosphorus compounds.

The above facts sufficiently show that muscular action is always accompanied by a chemical change in the composition of the acting muscle.]

The Brain, Spinal Cord, and Nerves.

Chemical analyses of the brain, spinal cord, and nerves are not calculated to throw much light on the functions of the nervous system in relation to the animal organism.

According to the analyses of Couerbe, the mass of the brain contains five different sorts of fat, viz. cholesterin, eleencephol,

cerebrot, stearoconot, and cephalot.[1] Frémy, who has paid much attention to the subject, found albûmen, cholesterin, two peculiar acids—cerebric and oleophosphoric acids, besides traces of olein margarin, and their acids, in the brain. These acids are partly free and partly (especially the oleophosphoric) combined with soda.

These fatty matters are contained almost exclusively in the white or medullary substance; after their removal a substance remains, analogous to the gray matter. Frémy has also detected these peculiar acids in the spinal cord and nerves.

The quantity of water in the brain is very considerable, and amounts to about 80%: Frémy estimates it at 88%, the remaining 12% consisting of 7% of albuminous matter insoluble in alcohol, ether, and water, and 5% of the aforesaid fats, and their compounds.

Denis found in the brain of a man aged 20 years:

Water	78·0
Albumen	7·3
Phosphorized fat	12·4
Extractive matter and salts	1·4

In the brain of a man aged 78 years he found:

Water	76·0
Albumen	7·8
Phosphorized fat	13·1
Extractive matter and salts	2·5

Vauquelin found in the human brain:

Water	70·00
Albumen	7·00
Fat	5·23
Phosphorus	1·50
Extractive matter	1·12
Acids, bases, and sulphur	5·15

Lassaigne has made the following analyses of the brain of an insane person:

	Cortical and medullary substance together.	Cortical substance.	Medullary substance.
Water	77·0	85·0	73·0
Albumen	9·6	7·5	9·9
Colourless fat	7·2	1·0	13·9
Red fat	3·1	3·7	0·9
Extractive matter, lactic acids, salts	2·0	1·4	1·0
Phosphates of lime, magnesia, and peroxide of iron	1·1	1·2	1·3

[The following table has been drawn up by L'Heretier[2] from

[1] See Vol. I, p. 81.

[2] Traité de Chim. pathol. p. 596.

his own researches. The numbers in each instance represent the mean of six analyses:

	Infants.	Youths.	Adults.	Aged persons.	Idiots.
Water	82·79	74·26	72·51	73·85	70·93
Albumen	7·00	10·20	9·40	8·65	8·40
Fat	3·45	5·30	6·10	4·32	5·00
Osmazome and salts	5·96	8·59	10·19	12·18	14·82
Phosphorus	0·80	1·65	1·80	1·00	0·85]

According to Vauquelin, the medulla oblongata and the spinal cord contain the same constituents as the brain, but a larger proportion of fats and a less amount of albumen, extractive matter, and water.

[L'Heretier found that the spinal cord of an adult was composed of:

Water	71·05
Albumen	7·30
Fat	8·25
Osmazome	11·50
Phosphorus	1·90

The nerves, according to the same chemist, contain more albumen, less solid and more soft fat than the brain.]

On boiling the nerves in alcohol a fluid fat exudes which sinks to the bottom of the vessel: on boiling them with water they swell but do not dissolve. The albumen of the medullary portion dissolves in a weak solution of potash, the fat swims on the surface, and the neurilemma remains. On treating the nerves with acetic acid the medullary portion is expressed by the contraction of the tubes, which are themselves unacted on.

Fat.

The fat contained in the fat-cells is a mixture of margarin and olein in man and the carnivora, of stearin and olein in the ruminantia. Human fat usually occurs in a fluid or semifluid state, consisting of a solution of margarin in olein, from which the margarin separates on cooling into microscopic stellar groups.

The Glands.

Our knowledge of the chemistry of the glands is very defective, and in all probability the analysis of these organs will never throw much light on the process of secretion in consequence of the utter impossibility of separating the nerves, ves-

sels, and cellular substance. Fromherz and Gugert attempted to analyse human liver. They found in 100 parts:

Water	61·79
Solid residue	38·21

The insoluble parenchyma formed 28·72%, and the portion soluble in water and alcohol 71·28% of the solid residue: 100 parts of dried liver contained 2·634 of salts, consisting of chloride of sodium, phosphate and a little carbonate of lime, phosphate of potash, and traces of peroxide of iron.

In the liver of the ox Braconnot found water 55·50, soluble matter 25·56, walls of vessels and membrane 18·94.

In certain morbid conditions of the system the liver becomes much affected. Its amount of fat is so extraordinarily increased in certain cases as to conceal the true structure, for the fat, as Rokitansky observes, not only occupies the place of the true glandular tissue, but all the tissues are permeated and the vascular substance perfectly overwhelmed. This morbid condition has been very frequently observed associated with pulmonary phthisis, and is a consequence of too luxurious a life, and the abuse of spirituous drinks. Fromherz and Gugert analysed a liver of this nature. It weighed twelve pounds, and had a soft caseous appearance. Its true organization appeared entirely destroyed. It contained a non-saponifiable fat with a small quantity of uncoagulated albumen, a little extractive matter, casein, salivary matter, a few shreds of vessels, chloride of sodium, and phosphate of lime: they found no cholesterin, fatty acids, or bilifellinic acid.

[A fatty liver analysed by Frerich,[1] yielded:

Water	73·09
Solid constituents	26·91
Fat containing phosphorus	17·26
Albumen	3·67
Vessels and hepatic cells	4·00
Water-extract	0·48
Alcohol-extract	1·50

A waxy liver (a variety of the above) yielded:

Water	80·20
Solid constituents	19·80
Fat containing phosphorus, and cholesterin	2·20
Albumen	3·50
Vessels and hepatic cells	3·60
Water-extract	7·00
Alcohol-extract	4·50

[1] Schmidt's Jahrbücher, vol. 48, p. 148.

The two following analyses have been made by Boudet:

	Fatty liver.	Healthy liver.
Water	55·15	76·39
Solid constituents	44·85	23·61
Animal matter dried at 212°	13·32	21·00
Saponifiable fat	30·20	1·60
Cholesterin	1·33	0·17]

The thyroid gland has been analysed by Fromherz and Gugert, and the thymus by Morin.

The kidneys have been submitted to analysis by Berzelius. From two experiments he concludes that the kidneys are made up of a congeries of minute vessels, and that the tubes contain a very albuminous acid fluid, in which there is no dissolved fibrin, and in which not a trace of urea can be detected.

[According to Boudet, the parenchyma of the lungs, freed as much as possible from blood and extraneous substances, is formed of the following chemical elements:—1st, a substance susceptible of transformation into gelatin by ebullition in water, (cellular tissue;) 2d, a substance soluble in cold water, precipitated by nitric acid, coagulated by heat, containing albumen and hæmatin; 3d, a substance analogous to casein; 4th, fibrin; 5th, free oleic and margaric acids; 6th, oleate and margarate of soda; 7th, cerebric acid; 8th, lactic acid; 9th, cholesterin amounting to ·05% of the weight of the lungs dried at 212°; 10th, the water amounting to 82%. The ash contained a considerable quantity of chloride of sodium and sulphate of soda, a small quantity of phosphate and carbonate of lime, and traces of silica and peroxide of iron.]

Otolithes.

The membranous labyrinth of the ear contains a rather viscid fluid, which, however, never occurs in sufficient quantity to admit of chemical examination. In this fluid there are found minute six- or eight-sided crystals (otolithes), which, however, are generally so worn at the angles and borders that the crystalline form can be no longer recognized. They appear to consist for the most part of the carbonates of lime and magnesia combined with animal matters, and not unfrequently with phosphates.

CHAPTER XII.

SOLID MORBID PRODUCTS.

Concretions.

THESE morbid products are of frequent occurrence. They are found in various organs, especially in those through which fluid glandular secretions are discharged. They then consist for the most part of the most insoluble constituents of that fluid, although they occasionally contain substances foreign alike to the secretion and to the whole organism, and produced by a depraved formative process. Concretions are, however, also met with in other situations, as the brain, the cavities of the heart, the arteries, &c.

The substances ordinarily entering into the composition of concretions are by no means numerous. Some concretions are formed of one constituent alone, while others have a mixed composition. The following substances must be viewed as true formative constituents, not as mere accidental admixtures: uric acid with its salts, uric oxide (xanthic oxide), cystin, hippurate of ammonia, basic and neutral phosphate of lime, ammoniaco-magnesian phosphate, oxalate of lime, carbonate of lime, carbonate of magnesia, fibrin, cholesterin, and biliphæin: the accidental components are mucus of the urinary and gall-bladders, albumen, hæmatoglobulin, bilifellinic acid, fat, extractive matters, chloride of sodium, and lactate of soda.

The principal object in the analysis of concretions is to determine the nature of the leading constituents, and this may be easily effected even by persons little skilled in chemical manipulation. A blowpipe, a little platinum foil, and a few tests, comprise all the requisite apparatus.

Qualitative analysis of concretions.

On heating a little of the concretion on platinum foil with the blowpipe, three things may happen: the portion tested may entirely disappear, or a part may disappear, while the rest

becomes whitened by incineration, or, finally, it may become blackened without, or with very slight diminution in size.

1. If the tested portion disappear entirely, it may consist of uric acid, urate of ammonia, or both, hippurate or benzoate of ammonia, uric oxide, cystin, cholesterin, biliphæin, fibrin, albumen, or hair.

a. It is uric acid if, when carbonized by exposure to heat on platinum foil, it gives off a peculiar animal odour resembling hydrocyanic acid, and diminishes to a scarcely visible residue; when a portion of the concretion heated with nitric acid dissolves therein with effervescence, and, after evaporation nearly to dryness, assumes, on the addition of ammonia, a beautiful purple tint; and when it dissolves thoroughly in a weak solution of caustic potash or its carbonate, and at the same time is insoluble in water, alcohol, and dilute hydrochloric acid.

b. It is urate of ammonia (which seldom occurs alone) if it behaves before the blowpipe, and with nitric acid, in just the same manner as uric acid, but at the same time, evolves an ammoniacal odour when heated on platinum foil, and develops a considerable amount of free ammonia on being triturated with caustic potash; and if it dissolves in boiling water.

c. It is uric or xanthic oxide if it burns without the peculiar odour of uric acid, if it dissolves without effervescence in hot nitric acid, and the evaporated solution when treated with ammonia assumes, not a rich purple, but a dark yellow colour; and if, finally, it is insoluble in a dilute solution of carbonate of potash.

d. It is cystin if it burns before the blowpipe with a blue flame, emitting at the same time, a pungent acid odour; if when treated with nitric acid it assumes (instead of a purple or yellow) a brown tint; if it dissolves in a dilute solution of carbonate of potash, and in caustic ammonia, and if it crystallizes from the latter in six-sided plates, easily recognized under the microscope.[1]

e. It contains benzoate of ammonia if alcohol extracts a substance which, after evaporation is soluble in water, and if,

[1] [In order to detect the presence of cystin a portion of the suspected calculus should be dissolved in a strong solution of caustic potash, and a solution of acetate of lead added in excess; the liquid must then be heated to the boiling point. If cystin be present insoluble sulphuret of lead is formed, which at first gives the liquid the aspect of ink, but is shortly precipitated, while oxalate of ammonia remains in solution.]

on the addition of hydrochloric acid to the aqueous solution, crystals are separated, which dissolve readily in alcohol and evolve an odour of benzoic acid.

f. It is cholesterin if the concretion exhibits a crystalline character, if the portion under examination burns with a bright flame, if it dissolves in boiling alcohol, and separates from it on cooling in crystalline plates or scales, and if it does not dissolve in caustic potash.

g. Biliary resin is a frequent constituent of biliary calculi, but never occurs alone. It may be easily recognized by its solubility in alcohol, by its extremely bitter taste, and by its separation from its alcoholic solution on the cautious addition of water.

h. It is biliphæin if it has a brown or ochre-yellow colour, if it evolves an animal odour on burning, if it is only slightly soluble in alcohol and water, but freely in caustic potash, communicating to it a dark brown tint, and if the addition of nitric acid to this solution causes the well-known change of colour.

i. It is fibrin if it softens when heated on platinum foil and evolves an odour of burnt horn, burning with a clear flame, and leaving scarcely any residue; if it dissolves in caustic potash from which it is precipitable by acetic acid, and finally, if it dissolves in an excess of acetic acid from which it is precipitable by ferrocyanide of potassium. It must be remembered that this description applies equally to albumen.

k. Concretions containing hair may be known by their light specific gravity, and by their appearance on making a section. When burned they develop an odour of burned horn. They dissolve in caustic potash, but in none of the other ordinary solvents.

2. If the portion submitted to examination becomes black on the first application of heat, and only slightly diminishes, it may consist of the earthy phosphates, carbonates, and oxalates, or of the urates with fixed bases, for then the uric acid becomes converted by heat into carbonic acid, and the bulk of the specimen does not very perceptibly diminish.

a. It is neutral phosphate of lime (which is not often the sole constituent) if, when the heat is continued, it fuses, and neither before nor afterwards effervesces with acids; if it dis-

solves readily in hydrochloric acid, from which it is precipitable as an amorphous powder by ammonia; and if, after the ammonia ceases to cause any further deposit, the filtered solution yields a precipitate to oxalate of ammonia.

b. It is basic phosphate of lime (which never occurs alone, but is often associated with the salt which will be next considered) if it easily burns white but does not fuse, even under the continued action of the blowpipe. It fuses, however, when combined with the following salt (*c*), and its fusibility is proportionate to the amount of the magnesian salt present: consequently such a compound may be mistaken for the neutral phosphate of lime. If it fuses before the blowpipe, and a solution in dilute hydrochloric acid yields a precipitate with ammonia, which, under the microscope, appears in the crystalline form represented in fig. 25; or if after the hydrochloric-acid solution has been saturated with ammonia, and all the lime thrown down by oxalate of ammonia, the filtered solution again yields a precipitate to caustic ammonia; then it is not neutral phosphate of lime, but the basic phosphate, in combination with the following salt. With the exception of the blowpipe test, the chemical characters of these two compounds are similar.

c. It is ammoniaco-magnesian phosphate (which usually occurs in calculi associated with one of the preceding compounds) if it develops a disagreeable ammoniacal odour before the blowpipe, and then fuses; if it dissolves, without effervescence, in hydrochloric and acetic acids, and, after the solution has been nearly saturated with ammonia, is not affected by oxalic acid, but is precipitated in the beautiful crystalline form represented in fig. 25, by an excess of free ammonia.

In proportion to the amount of basic phosphate of lime, mixed with the ammoniaco-magnesian phosphate, the less readily it fuses.

d. It is oxalate of lime if it does not fuse before the blowpipe, if it easily burns white, and distributes a brilliant light; if the heated specimen, when moistened with water, does not dissolve, but exhibits a strong alkaline reaction, and dissolves with effervescence in hydrochloric acid (or, if the heat has been long continued and very intense, without effervescence); and

if, after the solution has been neutralized by ammonia, oxalate of ammonia throws down a precipitate.

If the specimen is not affected by acetic acid, but dissolves readily in nitric or hydrochloric acid without effervescence, and is precipitated therefrom by ammonia; and if, farther, the nitric-acid solution evaporated nearly to dryness and treated with ammonia develops no purple tint, it consists of oxalate of lime.

e. It is carbonate of lime if it easily burns white before the blowpipe, and in other points resembles oxalate of lime after exposure to a red heat; if the fresh specimen dissolves with effervescence in acetic or hydrochloric acid, and the solution is not precipitated by ammonia; and if oxalate of ammonia throws down a precipitate from the ammoniacal solution.

f. It is urate of soda (which never occurs alone in urinary concretions, but is found, like the urate of potash, in small quantity in calculi of uric acid and the earthy phosphates,) if it fuses readily before the blowpipe, but burns white with difficulty, and communicates an intense yellow tint to the flame; if the residue (with the exception of particles of carbon) dissolves easily in water, to which it communicates an alkaline reaction, and dissolves with effervescence in hydrochloric acid, if the addition of bichloride of platinum to the filtered solution mixed with alcohol, producing no deposit; and if a fresh specimen dissolves in water on the application of heat, dissolves in nitric acid without effervescence, and the solution, after evaporation nearly to dryness, assumes a purple tint on the addition of ammonia.

g. It is urate of potash if it behaves exactly like urate of soda, (with the exception of communicating a yellow colour to the flame of the blowpipe;) and if a yellow precipitate is formed on the addition of bichloride of platinum to an alcoholic solution of the ash dissolved in hydrochloric acid. If, in conjunction with the occurrence of the yellow precipitate, the specimen communicates an intense yellow colour to the flame of the blowpipe, urate of soda is mixed with the urate of potash.

h. It is urate of lime (which never occurs alone, but is usually associated with uric acid in calculi) if it burns white

but does not fuse before the blowpipe, and then acts in the manner described in (*e*); and if a small portion of the fresh specimen dissolved in boiling water affords the ordinary evidence of uric acid when treated with nitric acid and ammonia. If the assay slightly fuses and runs together, and is then partially soluble in water, urate of soda or potash is mixed with the urate of lime; the solution has a strong alkaline reaction, and effervesces on the addition of an acid.

i. It is urate of magnesia (which occurs very rarely in calculi, and then only with uric acid) if it readily burns white before the blowpipe, but does not fuse; and if the residue is insoluble in water, but soluble without (or with very slight) effervescence in dilute sulphuric acid; and if caustic potash throws down a precipitate from this solution.

k. It contains silica (a rare constituent) if, after prolonged exposure to heat, and digestion of the residue in hot hydrochloric acid, an insoluble residue remains, which becomes white before the blowpipe, and fuses into a clear bead when mixed with carbonate of potash or soda.

3. The specimen may be partially consumed on exposure to heat, while the residue undergoes no further change under the action of the blowpipe. Concretions of this sort are by no means rare; they consist of a mixture of the compounds of the 1st and 2d classes. Indeed, calculi, composed merely of one of the substances already enumerated, are very rare, for although in one class of calculi uric acid may be the preponderating constituent, in another oxalate of lime, and in a third the earthy phosphates, we almost always find associated with these substances a certain amount of other matters; for instance, uric acid and the urates are of frequent occurrence in calculi chiefly composed of oxalate of lime or of the earthy phosphates.

Intestinal concretions consist for the most part of earthy phosphates with a little fat, extractive matters, and vegetable fibre; biliary concretions, of cholesterin mixed with a little bile-pigment and biliary resin, or of bile-pigment and biliary resin with a little cholesterin. Other classes of concretions (with the exception of arthritic concretions, which consist for the most part of urate of soda) are composed of earthy phos-

phates and carbonates combined with organic (albuminous, extractive, and fatty) matters.

In the analysis of mixed concretions we proceed in the following manner:

A. We incinerate a portion in a platinum crucible, and analyse the residue; if it burns white easily, the infusible earths preponderate; if it is difficult or impossible to obtain a white residue, and the ash remains fused and blackish, then the fusible earths or the alkalies preponderate. The residue may consist either of (1) earthy phosphates alone, which may be recognized by the rules given in 2, *a*, *b*, and *c*, or of (2) earthy phosphates and carbonates, the latter originating from earthy urates, or oxalate of lime. (In this case we recognize the presence of earthy carbonates (or of caustic earths, if the heat has been too intense and prolonged), by the rules laid down in 2, *d*, *e*, and *h*.)

4. The residue may consist of earthy phosphates and carbonates, and alkaline carbonates, if alkaline urates occur in the concretion. In order to detect the alkaline carbonates, the residue must be pulverised and extracted with water; on the evaporation of the decanted water the alkaline carbonates will remain, and may be recognized by the rules given in 2, *f*, and *g*. The portion insoluble in water is readily dissolved in dilute hydrochloric acid, usually with a slight effervescence.

Ammonia precipitates the earthy phosphates from this solution; after filtration oxalate of ammonia throws down the lime, and after a second filtration phosphoric acid and ammonia cause a precipitation of the magnesia.

5. Silica may be easily recognized by the rule given in 2, *k*.

B. The portion consumed and expelled by exposure to heat, consists of uric acid, of urate of ammonia, of the oxalic acid of oxalate of lime, which is converted into carbonic acid, of the carbonic acid of carbonate of lime, which is expelled at a high and prolonged temperature, of cystin, of ammonia yielded by ammoniaco-magnesian phosphate, of cholesterin or other fats, of bile-pigment, bilin, extractive matters, or other animal or vegetable substances mechanically entangled, as mucus, albumen, or vegetable fibre.

We may convince ourselves of the presence of uric acid by

observing the action of nitric acid and ammonia on a portion of the specimen, and its salts may be demonstrated by extraction with boiling water, and the addition of nitric acid to the nearly dried residue. The presence of oxalic acid may be shown by the digestion of the same portion in hydrochloric acid (the urates having been previously extracted by water); on the addition of ammonia, oxalate of lime is precipitated, which, after heating, dissolves with effervescence in the same acid. The presence of carbonic acid in the specimen may be shown by the effervescence produced on the immersion of a fragment in hydrochloric acid; the presence of ammonia dependent on the ammoniaco-magnesian phosphate, by its development on triturating a portion with caustic potash, the urate of ammonia having been previously removed by boiling water; the presence of cystin, by digesting the specimen in caustic ammonia, and observing the six-sided plates in which it crystallizes on the spontaneous evaporation of the ammonia; the presence of cholesterin (in human biliary calculi), of biliphæin (in the biliary calculi of cattle), of hair, and of vegetable fibre, may be determined after some practice by the internal structure and the colour of the concretion.

In this simple manner we may arrive at a knowledge of the qualitative composition of a calculus; the analysis is, however, in some respects facilitated by a knowledge of its origin. We know, for instance, that uric acid and its salts occur only in renal, vesical, and arthritic concretions; that the earthy phosphates occur equally in intestinal and vesical calculi; and that carbonate of lime is a common constituent of concretions in the brain, nose, and salivary glands; while, on the other hand, oxalate of lime is almost exclusively found in renal and vesical calculi, and cholesterin, bile-pigment, and biliary resin only in gall-stones.

On vesical and renal calculi in man.

The concretions of most importance in relation to practical medicine, are vesical and renal calculi and gravel. The constituents of urinary calculi, according to the statements of different observers, are, 1, uric acid; 2, urate of ammonia;

3, urate of soda; 4, urate of magnesia; 5, urate of lime; 6, benzoate or hippurate of ammonia; 7, oxalate of lime; 8, oxalate of ammonia; 9, uric or xanthic oxide; 10, cystin; 11, neutral and basic phosphate of lime; 12, ammoniaco-magnesian phosphate; 13, carbonate of lime; 14, carbonate of magnesia; 15, fibrin; 16, silica.[1] Mixed with these constituents we likewise meet with fat, extractive matters, albumen, vesical mucus, and peroxide of iron.

Of these constituents those numbered 1, 2, 7, 11, 12, are the most common, and occur in the largest quantity; those numbered 3, 4, 5, 13, 14, 16, are not of rare occurrence, but are usually met with in very small quantity in calculi composed of other ingredients. Uric oxide (9) has been only observed in three [four] cases; and cystin is by no means common.

Fibrin was once noticed by Marcet as a constituent of an urinary calculus, but Berzelius is inclined to suppose that in reality it was vesical mucus.

The presence of benzoate or hippurate of ammonia in urinary calculi, recorded by Brugnatelli, and of oxalate of ammonia, described by Devergie, is scarcely compatible with the great solubility of these salts.

The following points respecting the physical character of urinary calculi are deserving of notice:

The form varies in accordance with the seat of origin and the chemical composition; the oval or spheroidal is the most frequent; round calculi are often compressed laterally, and renal concretions sometimes assume a polygonal or even a branching coralline form; in the ureters cylindrical calculi with prominences and depressions have been described. The surface is smooth, and presents few irregularities in calculi of uric acid; it is flat and more or less rough in many phosphatic calculi; earthy and easily triturable in urate of ammonia calculi; tuberculated, as we sometimes observe in calculi of uric acid, the urates or cystin; or armed with prominences and asperities in the oxalate of lime calculi.

The colour of these concretions varies for the most part from a pale yellow to a yellowish-red, brown, or brownish-green.

Calculi of the earthy phosphates are colourless, or nearly so;

[1] [To these Heller has recently added urostealith.]

calculi of uric acid and the urates vary from a yellow to a reddish-yellow or brown; calculi of oxalate of lime are yellow, yellowish-brown, brownish-green, or blackish-green. Calculi of uric oxide are of a cinnamon-yellow colour, and those of cystin of a yellow tint. In size and weight they present, as might be supposed, the greatest variety; their specific gravity varies from 1·213 to 1·975. Calculi of oxalate of lime exhibit the greatest density, those which consist of the earthy phosphates, and especially of ammoniaco-magnesian phosphate, are the lightest.

With respect to absolute weight, urinary concretions may vary from one or two grains (when they merely form gravel) to several ounces. Some cases of enormous and almost incredible size are related: Morand describes a stone in his possession weighing 6 pounds and 3 ounces, Lister describes a stone of 51, and Earle one of 44 ounces; the latter was 16 inches in circumference. With regard to the number of calculi that may occur in the same person, we may mention that Murat found 678 in the bladder of an old man, and nearly 10,000 in his kidneys. Buffon's bladder contained 59 calculi. When several calculi exist in the bladder their form becomes modified, and they are usually more or less flattened by mutual apposition and friction. I am in possession of a calculus consisting of two portions; the upper is small, weighing about two ounces, triangular, and provided with three equal convex facettes, exactly fitting into the depression of the larger inferior part, which is of an oval form and weighs about five ounces. There can be no doubt that this peculiarity of form arose from the frequent rotation of the calculi.

The internal structure of urinary calculi is of importance; a section may exhibit either an uniform texture throughout, or concentric strata arranged around a nucleus. If the calculus is formed of a single ingredient, its fractured or cut surface appears coarse and finely granular, and sometimes presents a radiating appearance, especially in uric-acid calculi: it is earthy and fragile, and does not present any regular arrangement in calculi of urate of ammonia: it is dense and conchoidal in oxalate of lime, and crystalline in cystin. Calculi of phosphate of lime, on the other hand, exhibit an almost fibrous structure, distinguished by parallel striæ. Calculi in which ammo-

niaco-magnesian phosphate is the predominating ingredient exhibit a porous internal surface, studded here and there with crystals.

In calculi consisting of a nucleus and of laminæ deposited round it, it is important to ascertain whether the nucleus and the concentric laminæ are identical or different in their composition.

The nucleus may consist either of one of the ordinary constituents of urinary concretions or of a foreign body introduced into the bladder, as for instance, a fragment of wood, a grain of corn,[1] &c. The laminæ may have the same chemical constitution as the nucleus, and only differ from it in the period of their deposition, as is the case with calculi of uric acid, urate of ammonia, uric oxide, and earthy phosphates: or they may differ from the nucleus in their composition; in this case we may always infer that changes have taken place in the character of the urinary secretion; for instance, if the nucleus consist of uric acid, and is surrounded by a concentric layer of the earthy phosphates, the urine must have been first constantly acid, and subsequently neutral or alkaline.

I now proceed to the consideration of the most common urinary calculi.

Combustible calculi.

I. *Calculi of uric acid* are by no means rare; their character have been already described in page 431; they may be distinguished from calculi of urate of ammonia by the solubility of the latter, and the insolubility of the former in a sufficient quantity of boiling water. They are of every possible size, their colour is sometimes (but very rarely) white, most commonly yellow, rose-coloured, or brown; their surface is smooth, sometimes even polished, and occasionally presents rounded verrucose protuberances. Their fractured surface presents either a crystalline appearance, or is dense with concentric strata merging into each other. The nucleus is crystalline, and the surrounding laminæ hard. I have found a minute

[1] [Professor Malago has recently extracted a calculus, of which the nucleus was a globule of mercury. *Filiatre Sebezio*, 1845.]

grain of urinary gravel in the centre of several calculi of uric acid, and the central portions are often darker coloured than the peripheral. The uric acid in these calculi is never pure, but is always mixed with colouring matter—the uroerythrin (which always accompanies uric acid),—frequently with alkaline urates, and occasionally with small quantities of earthy phosphates. A very minute quantity of fat and of extractive matter occurs in this as well as in most other sorts of urinary calculi.

In order to obtain an accurate knowledge of the composition of a calculus, it must be sawed through the centre, and the different strata submitted to distinct analyses if they present any variation in their physical characters: it does not often happen that a calculus which consists externally of uric acid is composed in its interior of earthy phosphates, oxalate of lime or cystin, but on the other hand uric acid often forms a nucleus to calculi formed of other constituents. In order to determine whether fixed alkaline urates, or earthy phosphates are contained in a calculus, a portion must be incinerated and the residue analysed. If they are present they may be determined by the rules given in 2, *a*, *b*, *c*, *f*, *g*, *h*, and 3.

A portion of each lamina, or if the calculus is uniform throughout, some of the dust separated in the operation of sawing, is reduced to an impalpable powder; a weighed quantity is placed in a small porcelain basin, and after being warmed for some time on the water-bath, is placed under the exsiccator in order to remove every trace of moisture. A known portion of the dried powder is placed in a small glass flask, and repeatedly extracted with ether, whereby the fat is removed; and the residue is boiled with alcohol of specific gravity ·850, which takes up some extractive matter. The powder is then boiled with distilled water till nothing further can be removed by that menstruum. On evaporating the watery solution in a small porcelain capsule we obtain the urates as a residue. If it is requisite that this part of the analysis should be carried further, we dry the residue and weigh it; we then heat it in a little water and add hydrochloric acid; the uric acid separates, and the bases combine with the hydrochloric acid. The uric acid is collected on a filter, washed with water, dried, and weighed; the hydrochloric-acid solution is evaporated, and

yields a residue of hydrochlorate of ammonia, and probably the chlorides of sodium and calcium. In order to separate these substances the dried residue is first weighed, and then dissolved in water; some ammonia, and subsequently oxalate of ammonia are added, in order to precipitate the lime. The fluid after filtration is evaporated, and the dried residue exposed to a strong heat: the chloride of sodium is left, and the chloride of ammonium may be estimated by the loss of weight. The bases are calculated from the lime which is left after the exposure of the carbonate of lime to heat, and from the chlorides of sodium and ammonium, and are combined with the uric acid.

The portion of the powdered calculus not taken up by water is treated with dilute hydrochloric acid, which dissolves any earthy phosphates that may happen to be present. They are precipitated by the addition of ammonia to the acid solution, and must be then collected on a filter, washed, dried, and weighed. The uric acid (the remaining constituent) must be perfectly dissolved in caustic potash, from which it must be precipitated by super-saturation with hydrochloric acid. It must be then washed on a filter, dried, and weighed. The acid solution usually contains a trace of organic matter, (vesical mucus or albumen;) its presence may be detected by the addition of a little ferrocyanide of potassium, which causes a precipitate.

II. *Calculi of urate of ammonia.* This form of calculus is somewhat rare, and indeed its existence was regarded as uncertain till Prout determined the point beyond a doubt. According to Fourcroy these calculi are usually small, occur more frequently in children than in adults, have a whitish or clay-colour, a smooth or tuberculated surface, and an earthy fracture exhibiting concentric strata. Yellowly found that of 59 small stones taken from a man aged 45 years, 24 consisted of urate of ammonia and 35 of uric acid. Urate of ammonia occurs, however, most frequently mixed with other constituents, especially with uric acid: moreover it often forms the nucleus of large calculi, or occurs as a stratum between a nucleus of uric acid and an external coating of phosphates; in such cases, however, it is not pure but mixed with crystals of

uric acid, or oxalate or phosphate of lime. Urate of ammonia acts before the blow-pipe in just the same manner as uric acid, and their reactions with nitric acid are also similar: they may, however, be readily distinguished by the comparative solubility of the former in boiling water, and by the evolution of ammonia that takes place on triturating it with caustic potash. In a careful examination of a calculus of urate of ammonia, the first point is to ascertain if other constituents are present, which is usually found to be the case. If there is a residue left after heating it before the blow-pipe, that residue may consist of earthy phosphates, or earthy or alkaline carbonates: the alkaline carbonates correspond with the alkaline urates, the carbonate of lime with the oxalate of lime. In this case the calculus must be reduced to a very fine powder and dried; a weighed portion must then be freed from fat and extractive matter by ether and alcohol, and afterwards repeatedly boiled in small quantities of distilled water, till the water is no longer affected. When the calculus is finely powdered the urate of ammonia dissolves with tolerable facility in boiling water. The earthy phosphates and the oxalate of lime must be extracted with dilute hydrochloric acid,[1] precipitated by ammonia, dried, weighed, and exposed to a high temperature. If we again dissolve this residue in hydrochloric acid, and throw down the earthy phosphates with ammonia, chloride of calcium remains in solution, arising from the oxalate of lime. Whatever remains unacted on by dilute hydrochloric acid is uric acid.

The urates of soda and potash, as well as the urate of lime are (as I have already mentioned) often found in calculi of uric acid; they likewise occur in calculi of urate of ammonia. All these urates are soluble in boiling water; their mode of separation has been already described. If urate of magnesia should also be present (which is probably seldom the case), a different method of separation must be adopted. Hydrochloric acid is added to the evaporated aqueous solution in order to precipitate the uric acid; the acid solution, after filtration, is evaporated on the water-bath, and we then obtain a residue of

[1] [Unless the hydrochloric acid is tolerably strong, it will not dissolve the oxalate of lime.]

mixed chlorides. The dried residue, after being weighed, is moistened with a little concentrated hydrochloric acid, and afterwards treated with anhydrous alcohol, which takes up the chloride of magnesium. The alcoholic solution is treated with a little carbonate of potash, evaporated, and dried in a platinum crucible heated to incipient redness. After the extraction of the potash, the magnesia remains. The chlorides of calcium, sodium, and ammonium, must be separated in the ordinary manner.

III. *Calculi of uric (xanthic) oxide.* Calculi of this substance usually contain no other constituent, with the exception of a little animal matter. Uric oxide was first met with by Marcet, forming a calculus weighing 8 grains; some years afterwards a few minute concretions of the same nature were described by Laugier; more recently it was discovered by Stromeyer in a calculus weighing 338 grains, and as large as a pigeon's egg, extracted by Langenbeck; [and a fourth specimen weighing 7 grains, has been lately described by Dulk.[1]] Their external surface is smooth and polished, and of a cinnamon-brown colour. Their cut surface is of a brown flesh-colour, and consists of concentric laminæ easily separable from each other. In point of hardness they resemble uric acid, and when rubbed they assume a waxy appearance. Although uric oxide is of rare occurrence, it need never escape detection with ordinary care. The fact of its entire destruction before the flame of the blow-pipe at once distinguishes it from the calculi which contain fixed constituents: by its behaviour with nitric acid, and with carbonate of potash (in which uric acid dissolves, but uric oxide is insoluble,) it may be distinguished from uric acid, which it resembles in many respects.

In order to make a full analysis of a calculus of this description, it must be first pulverised, and then everything soluble in ether, alcohol, and water removed. If uric acid is associated with it, carbonate of potash serves to separate the acid from the oxide; if earthy phosphates or oxalate of lime are present, they must be removed by dilute hydrochloric acid. Any urates that are present are taken up by water.

[1] [Simons', Beiträge, p. 413: moreover Unger has discovered minute traces of a substance closely allied to uric oxide, if not identical with it, in guano.]

IV. *Calculi of cystin.* Calculi of cystin, although rare, are more common than those of uric oxide. Although sometimes mixed with other constituents, cystin most commonly forms the sole ingredient. These calculi seldom attain any great size; they are usually small, round, smooth, and of a yellow colour. In consistence such a calculus is soft; the cut surface presents a semi-transparent, confusedly crystalline appearance; not however laminated. When broken, it appears to be made up of small crystals of a waxy lustre, the margins of which are rounded. The microscope affords the best means of recognizing the existence of cystin: if we dissolve a fragment in caustic ammonia, and allow it to evaporate spontaneously, crystals are deposited in six-sided tables or prisms. The peculiar behaviour of cystin before the blowpipe distinguishes it not only from calculi with fixed ingredients, but also from those of uric acid and uric oxide. It is also distinguished from the latter (with which, however, it has never yet been found associated) by its solubility in carbonate of potash, and in dilute hydrochloric acid; and from the former by its solubility in dilute hydrochloric, phosphoric, and even oxalic acid. When cystin is associated in calculi with other constituents, it is most commonly found to alternate with uric acid. Thus Henry found a nucleus of cystin, and an external layer of uric acid; and Yellowly found an external layer of cystin and a nucleus of uric acid. It is worthy of remark that Bley, in examining two calculi taken from the same man, found in one, cystin associated with carbonate of magnesia and ammoniaco-magnesian phosphate; in the other the cystin was displaced by uric acid. The calculus that contained the cystin was reniform, compressed, and flattened; of a yellow colour and weighed 1·75 grains. It exhibited a stratified appearance internally, and when exposed to heat left scarcely a trace of ash. After the removal of the earthy matters by hydrochloric acid, there remained a residue soluble in potash, which, on the addition of acetic acid and evaporation, deposited small six-sided crystals.[1]

It need scarcely be mentioned that if in a calculus containing cystin there is any perceptible difference between the

[1] It seems strange that the cystin did not dissolve in the hydrochloric acid. The case is recorded in Buchner's Repert., 2d series, vol. 2, p. 165.

nucleus and the surrounding strata, they must be analysed separately.

V. *Calculi formed of protein-compounds. Fibrinous calculi,* according to Marcet.

All urinary calculi contain an organic matter, which, by prolonged digestion is soluble in acetic and in dilute hydrochloric acid, from which solutions it may be precipitated by ferrocyanide of potassium. It is readily soluble in caustic potash, but is insoluble in water, alcohol, or ether: it consists in most cases of the mucus of the bladder, occasionally of albumen. Marcet described a remarkable calculus consisting entirely of protein-compounds, and regarded by him as composed of fibrin. It had the appearance and consistence of yellow wax; its surface was irregular, but not rough; internally it exhibited a fibrous character, and was, to a certain degree, elastic. When burned it evolved the odour of burning horn, and left a porous carbonaceous residue. It was insoluble in alcohol, ether, or water, but dissolved in caustic potash, from which it was precipitated by hydrochloric acid. It dissolved slowly in nitric acid, and when boiled in acetic acid, swelling previously to dissolving. It was precipitated from its acetic acid solution by ferrocyanide of potassium. In its solubility in nitric acid it does not (as Berzelius remarks) correspond very well with the properties of fibrin; its characters, as given by Marcet, lead more to the supposition that it was vesical mucus. Morrin has likewise described a calculus remarkable for the quantity of organic protein-like substance contained in it. It was associated with phosphate of lime, and amounted in the nucleus to only 10%, in the second layer to 18%, and in the third to 70% of the weight of the calculus. Alcohol took up a little fat. The substance was slightly soluble in acetic, more so in nitric acid: in caustic potash it swelled, became viscid, and partially dissolved.

Incombustible or partially combustible Calculi.

VI. *Calculi of oxalate of lime* are next in frequency to those of uric acid and the earthy phosphates. Their form is very characteristic; they are usually spherical, but their whole surface is studded by verrucose, tuberculated elevations, or

even by sharp angular projections. It is from the former and most common of these appearances that they have received the name of mulberry calculi.

The size of these calculi varies from that of a hempseed to a pigeon's egg, and is occasionally even larger. Thus out of thirty-three calculi of pure oxalate of lime examined by Smith there was only one that weighed an ounce and a half. Their colour varies; they are white, bright yellow, yellowish-brown, and occasionally dark green. The largest are usually the most darkly coloured. The fracture is usually firm, hard, finely-granular and conchoidal; but calculi have been observed by Berzelius which consisted of an aggregate of closely connected sharp angular crystals. Their specific gravity is higher than that of other calculi. Hence it is evident that the physical characters alone are sufficient to prevent a calculus of this nature from being mistaken for one consisting of uric acid or of the earthy phosphates. The chemical characters are, however, equally distinct. It is distinguished from uric acid by its readily burning white before the blowpipe: it is distinguished from the earthy phosphates by its moistened residue exhibiting an alkaline reaction towards red litmus paper, and, if the heat has not been too intense, by its dissolving in hydrochloric acid with effervescence, by ammonia added to saturation producing no precipitate in this solution, but by a deposit being at once observed on the subsequent addition of oxalate of ammonia: it is distinguished from carbonate of lime by its dissolving in hydrochloric acid without effervescence, and by the solution being precipitated by ammonia: and, finally, it is distinguished from urate of lime by its insolubility in boiling water. Although oxalate of lime mixed with a little organic matter (mucus and colouring matter) is generally the sole constituent of mulberry calculi,[1] it is sometimes associated with uric acid, urate of ammonia, or phosphate or carbonate of lime. After what has been already stated, the separation of these substances can scarcely be considered difficult. Ether and alcohol remove fat and extractive matters, water removes the urates, hydrochloric acid the earthy phosphates and oxalate of lime: there can then remain nothing but uric acid with vesical mucus or coagulated albumen, and possibly a little silica. The hydrochloric-acid

[1] [Our own experience is opposed to this statement.]

solution is super-saturated with ammonia, and the precipitate washed with a weak ammoniacal solution. It is exposed to a red heat, and dissolved in hydrochloric acid; the earthy phosphates are then precipitated by ammonia, and the lime separated from the filtered solution by oxalate of ammonia. In order to analyse the residue insoluble in hydrochloric acid, it must be boiled in caustic potash and filtered; the uric acid and silica must be thrown down by an excess of hydrochloric acid; if the precipitate is washed, weighed, and submitted to a red heat, we obtain the silica as a residue.

The amount of animal matter, and especially of pigment, is generally larger in these than in any other calculi. The animal matter seems to consist partly of protein-compounds, and partly of extractive matter. Whether the colouring matter is due to the hæmatin of the blood, or to uroerythrin, has never been determined.

VII. *Calculi of ammoniaco-magnesian phosphate and phosphate of lime.* These calculi are of the most common occurrence next to those of uric acid. They sometimes attain a very large size; they are usually globular or spheroidal; their colour is white, gray, or dull yellow; their fractured surface is less earthy than in the preceding calculi, and is interspersed with sparkling crystals; and although in general friable, their texture is occasionally compact and dense. When laminated, which is seldom the case, the intervals between the layers contain glistening crystals of ammoniaco-magnesian phosphate. On heating a fragment of a calculus of this nature on platinum foil an odour of ammonia is developed: it does not burn white so readily as the oxalate of lime, since the ammoniaco-magnesian phosphate, if present in any quantity, fuses and produces a grayish white enamel.

The moistened ash does not affect red litmus paper; it dissolves in hydrochloric acid without effervescence, and may be precipitated from it by ammonia. As these calculi contain a little fat and extractive matter, it is requisite in making a careful analysis that, after being pulverized, they should be extracted with ether and alcohol; on dissolving the residue in hydrochloric acid a small amount of flocculent matter is usually observed, arising probably from vesical mucus. The earthy

phosphates are precipitated from this acid solution by ammonia, and after being washed, are exposed to a red heat. Calculi of phosphate of lime and ammoniaco-magnesian phosphate often contain uric acid, the alkaline urates, and sometimes oxalate and carbonate of lime. The alkaline urates are, in that case, extracted with boiling water; on digesting a portion of the residue in dilute hydrochloric acid, the earthy phosphates are dissolved and the uric acid remains; if carbonate of lime is present, effervescence is observed on treating a little of the powdered calculus with hydrochloric acid; the lime may be precipitated by oxalate of ammonia, after the earthy phosphates have been thrown down from the acid solution by caustic ammonia. If oxalate of lime is present, the powdered calculus (the urates having been previously removed) after a short exposure to heat (but not before) effervesces on the addition of hydrochloric acid. The large calculus noticed in page 439 consists principally of earthy phosphates with small quantities of the urates of ammonia and soda lying one above the other in laminæ. It contains a nucleus about the size of a nut, of a mulberry appearance, consisting of oxalate of lime, and in the centre of this is a nucleolus of the size of a large pea, consisting almost entirely of uric acid.

VIII. *Calculi of neutral phosphate of lime* are very rare: they were first described by Wollaston. Their surface is usually pale brown, and so smooth as to appear polished. On sawing through a calculus of this nature it is found very regularly laminated, and the laminæ in general adhere so slightly to each other as to separate with ease into concentric crusts. Each lamina is striated in a direction perpendicular to the surface, as from an assemblage of fibres. In these as in all other calculi we meet with a certain amount of animal matter, supposed by Berzelius to be identical with that which is associated with phosphate of lime when we precipitate that salt from the urine. Hence on heating a portion before the blowpipe it becomes charred, and evolves an odour of burned horn; it finally burns white and fuses, which distinguishes it from the basic phosphate of lime, which is infusible before the blowpipe. Since, however, ammoniaco-magnesian phosphate readily fuses before the blowpipe we must examine previously that none of it is present.

Basic phosphate of lime or bone-earth never occurs as the sole constituent of an urinary calculus; the same is the case with ammoniaco-magnesian phosphate.[1]

IX. *Calculi of carbonate of lime.* Calculi consisting merely of carbonate of lime and animal matter are somewhat rare. Smith found 18 such calculi in the bladder of a young man, and Brugnatelli mentions 48 pisiform concretions of the same nature taken from a young man, and 16, the size of a nut, from a woman. According to Berzelius they are generally white or gray, but sometimes yellow, brown, or red; the tint depending on the animal matter. The formation of these calculi is due to an alkaline condition of the urine, and to the absence of the ordinary phosphates. On heating a fragment before the blowpipe, it evolves an odour of burned bone, and readily burns white. On treating the residue with hydrochloric acid effervescence is observed, unless the heat has been very intense and prolonged, in which case the carbonate is converted into caustic lime, and it dissolves without effervescence: in this case it is also soluble in water and forms an alkaline solution. If a fragment of the unheated calculus is pulverized and treated with dilute hydrochloric acid, it dissolves with effervescence and leaves a residue of vesical mucus.

Although it seldom occurs as the principal ingredient, it is often found associated with other constituents, especially with phosphate of lime, in urinary calculi.

I have examined two yellow calculi of the form and size of a pea, taken from the kidney; they consisted of carbonate and phosphate of lime. Proust also mentions vesical calculi composed of carbonate and phosphate of lime. Prout was the first who detected carbonate of lime in urinary calculi: it was in that instance associated with phosphate of lime and traces of urate of lime. Walther describes six calculi in which the nucleus was urate of ammonia, while the cortex was composed of carbonate and phosphate of lime. Prout mentions a mulberry calculus in which the external layer was soft and consisted of oxalate and carbonate of lime, the second of carbonate and phosphate of lime, and the third of phosphate of lime.

[1] [A human calculus composed entirely of ammoniaco-magnesian phosphate is described by Scharling, 'On the Chemical Discrimination of Vesical Calculi,' translated by Dr. Hoskins, p. 55.]

Brugnatelli states that he examined an urinary secretion consisting of carbonate and oxalate of lime, and benzoate of ammonia.

When carbonate and oxalate of lime occur together, the calculus dissolves in hydrochloric acid with effervescence, both before and after heating. Before the application of heat it is partially soluble in acetic acid with effervescence, the oxalate remaining undissolved.

On dissolving a portion of the calculus in dilute hydrochloric acid, and adding ammonia, we precipitate the oxalate of lime; the lime corresponding to the carbonate may then be precipitated from the filtered solution by oxalate of ammonia. The oxalate of lime precipitated by ammonia may be easily mistaken for phosphate of lime; all ambiguity may, however, be avoided by recollecting that the oxalate may be converted by heat into carbonate of lime, which dissolves with effervescence in acids from which it is not precipitable by ammonia, while the phosphate of lime is unaffected by heat, and dissolves without effervescence in hydrochloric acid from which it may be thrown down by ammonia. When carbonate of lime is associated with oxalate and phosphate of lime, the calculus dissolves with effervescence in hydrochloric acid both before and after heating. In this case the oxalate of lime may be readily overlooked, but on dissolving a fragment of the calculus in hydrochloric acid, and precipitating with ammonia, the oxalate and phosphate of lime are thrown down together, while the carbonate of lime exists in the filtered solution as chloride of calcium, and may be precipitated by oxalate of ammonia. On drying and gently heating the mixture of oxalate and phosphate of lime, the oxalate becomes converted into carbonate. We then dissolve the heated residue in hydrochloric acid, precipitate the phosphate of lime with ammonia, filter, and throw down the lime from the filtered solution with oxalate of ammonia. This lime corresponds with the original oxalate. When the carbonate is mixed with urate of lime, the latter must be taken up with boiling water.

Carbonate of magnesia is only rarely associated with carbonate of lime in urinary calculi, although Berzelius supposes that they always occur together. In order to separate them, they must be dissolved in hydrochloric acid, and the chloride of magnesium then taken up by alcohol.

An analysis of a calculus containing a considerable amount of carbonate of magnesia is given in p. 458.

This salt is of frequent occurrence in calculi of the lower animals.

[*Urostealith.* We have already (see page 326) noticed Heller's discovery of urostealith.

The concretions that were discharged were round and had not the appearance of being fragments of a larger calculus; in consequence of the locality of the pain it was presumed that they were renal calculi. Altogether a little more than a drachm of urostealith was collected. The concretions varied from the size of a hempseed to that of half a small nut. Most commonly they were of the size of a pea, and either consisted of pure urostealith or had an outer coating of ammoniaco-magnesian phosphate.

Urostealith is most readily detected by the effects of heat and combustion. A fragment placed on platinum foil and heated remains for some time solid, then commences to fuse without thoroughly melting, swells, and diffuses much vapour, giving off an extremely peculiar and pungent odour, resembling that of shell-lac and benzoin. The odour is so strong as to be distinctly evolved by the smallest piece of urostealith. After fusing and swelling up, it catches fire (if touched by the flame of the lamp), and burns with a clear yellow flame. A voluminous coal is left which, when thoroughly burned, leaves a very minute alkaline ash, consisting principally of lime.

When boiled in water urostealith becomes soft but does not dissolve. Warm alcohol dissolves it, but with difficulty; when the alcohol is evaporated and the residue burned the fragrant odour is developed. Ether dissolves it pretty freely; on evaporation the urostealith is left in an amorphous form, and on continuing a gentle heat it assumes a well-marked violet tint. It dissolves readily in a hot solution of caustic potash, forming a brown soap; and on treating this solution with an acid the urostealith again separates as amorphous fat. The carbonates of potash and soda act similarly but more slowly. When heated with nitric acid it yields a colourless solution, a slight quantity of gas being developed: on treating the residue (after evaporation) with ammonia or potash it becomes of a dark yellow colour.[1]]

[1] Heller's Archiv für physiologische und pathologische Chemie, vol. 2, pp. 1-12.

On the laminæ of vesical and renal calculi, and on their quantitative analysis.

In the analysis of urinary calculi it is of the greatest importance to observe the order in which the different laminæ were deposited, and in connexion with this subject, and with the relative proportion in which different sorts of calculi occur, we may especially refer—1, to Brand's[1] paper on the urinary calculi in the Hunterian Museum; 2, to Marcet[2] on the calculi at Guy's Hospital; 3, to Wood[3] on the calculi at the Canterbury Hospital, the Windmill Street School, and Mr. Cross's collection; 4, to Yellowly,[4] and 5, to Marcet, for their account of the Norwich Hospital collection; 6, to Henry[5] on the Manchester collection; 7, to Smith on the Bristol collection; 8, to Rapp[6] on the Swabian collection; 9, to Lecanu and Segalas[7] on Segalas's collection; 10, to Scharling on the calculi in the Copenhagen Museum; and, 11, to Taylor[8] on the calculi in the Museum at St. Bartholomew's Hospital.

The following table affords a view of the relative proportions in which the most common calculi occur:

According to	Oxalates.	Urates.	Phosphates.	Total.
1. Brand, in Hunterian Museum =	1 : 13·5	1 : 2·46	1 : 2	150
2. Marcet, in Guy's Hospital . .	1 : 3	1 : 4	1 : 3	87
3. Wood, in Canterbury Hospital .	1 : 3	1 : 1·18	1 : 7	167
4. Yellowly, in Norwich Hospital .	1 : 2·9	1 : 3	1 : 76	329
5. Marcet „ ditto „ .	1 : 3	1 : 2·7	1 : 32	181
6. Henry, in the Manchester Hosp.	1 : 10·33	1 : 2·2	1 : 85	187
7. Smith, in the Bristol Hospital .	1 : 3·33	1 : 3·33	1 : 10·89	218
8. Rapp, in Swabia	1 : 1·43	1 : (11·5) 1·21	1 : 10·1	81
9. Scharling, in Copenhagen Museum	1 : 6·6	1 : 1·6	1 : 6·2	155

[1] Philosophical Transactions, 1808.
[2] An Essay on the Chemical History and Medical Treatment of Calculus Disorders.
[3] London Medical and Physical Journal, vol. 57.
[4] Philosophical Transactions, 1829.
[5] Medico-Chirurg. Transactions, vol. 10.
[6] Naturwissenschaftliche Abhandlungen. Tübing. 1826.
[7] Journal de Pharmacie, 1838, p. 463.
[8] London and Edinburgh Philosophical Magazine, 1838.

The following TABLE contains the results collected and published by Martin, in his Inaugural Dissertation (de Lithogenesi), in which I have also incorporated the subsequent investigations of Lecanu and Segalas, Scharling and Taylor.

(*The figures at the head of the Table refer to the above collections, the figures* [redacted] *the columns to the number of calculi of each kind occurring in each collection.*)

Nucleus or whole calculus.	[redacted] the 1st layer with	In the 2d layer with	In the 3d layer with						6.
Oxalate of lime				6	22	..	20	41	11
a. resembling hempseed				..	..	1			
b. mulberry calculus				..	..	4	..	..	..
Ditto	Uric acid			..	..	5	10	..	11
Ditto	Ditto	Urate of ammonia		..	..	..	1	..	..
Ditto	Ditto	Oxalate of lime	Earthy phosphates	..	..	..	1		
Ditto	Ditto	Earthy phosphates		5	..	..	2	..	7
Ditto	Uric acid and earthy phosphates			..	..	2			
Ditto	Uric acid and oxalate of lime	Uric acid		..	..	..	1		
Ditto	Urate of ammonia, oxalate of lime, and earthy phosphates			..	..	..	..	..	..
Ditto	Urate of ammonia	Uric acid		..	..	..	1	..	..
Ditto	Phosphate of lime	Ditto		..	..	..	3		
Ditto	Ditto	Uric acid with phosphate of lime		..	..	1			
Ditto	[illegible] phosphate			..	..	..	..	1	
Ditto	[illegible]			..	..	1	15	..	16
Ditto	[illegible]	Oxalate of lime		..	..	1			
Ditto	Earthy phosphates and uric acid			..	..	4	..	..	..
c. Oxalate of lime with uric acid				..	..	1	..	..	..
Ditto	Uric acid	Earthy phosphates		..	..	1	..	..	..
Ditto	Uric acid and oxalate of lime.								
Ditto	Oxalate of lime and ammoniaco-magnesian phosphate			..	..	1			
Ditto	Oxalate of lime	Earthy phosphates & oxalate of lime	Earthy phosphates	..	..	1			

d. Oxalate of lime with phosphate of lime				..	..	1								
Ditto	Earthy phosphates, oxalate of lime, and uric acid			..	..	..	..	..	..	..	..	2		
Uric acid				..	..	..	81	66	71	74	7	..	32	11
a. Pure uric acid				16	16	45								
Ditto	Oxalate of lime			..	..	5	11	15	..	..	53			
Ditto	Ditto	Uric acid		..	..	..	4							
Ditto	Ditto	Urate of ammonia		..	..	..	2							
Ditto	Ditto	Phosphate of lime		..	..	..	1							
Ditto	Ditto			..	..	4	1	..	..	..	(28)	..	..	1
Ditto	Ditto			..	..	..	..	..	..	..	..	1		
Ditto	Oxalate of lime with uric acid			..	..	..	8							
Ditto	Oxalate and phosphate of lime			..	..	..	1							
Ditto	Oxalate of lime & earthy phosphates			..	..	..	1							
Ditto	Urate of ammonia			..	..	..	..	37	..	..	..	..	1	
Ditto	Ditto	Oxalate of lime		..	..	..	..	2						
Ditto	Ditto	Earthy phosphates		..	..	..	1	..	..	..	..	..	13	3
Ditto	Phosphate of lime			..	..	..	1	2						
Ditto	Ditto	Oxalate of lime	Ammoniaco-magnesian phosphate	..	..	1								
Ditto	Ditto	Earthy phosphates		..	..	..	2							
Ditto	Earthy phosphates			..	..	12	10	..	39	12	9	..	6	6
Ditto	Earthy phosphates and uric acid			..	..	4								
Ditto	Ditto	Earthy phosphates		..	..	1								
b. Uric acid with oxalate of lime				..	6	11								
Ditto	Oxalate of lime with ammoniaco-magnesian phosphates			..	..	1								
Ditto	traces of carbonate of lime			..	..	..	..	..	..	..	..	1		
Ditto	Uric acid and oxalate of lime	Uric acid with more oxalate of lime	Oxalate of lime, earthy phosphates, and traces of uric acid	..	..	..	..	..	..	..	..	1		

		In the 2d layer with	In the 3d layer with
and earthy phosphates			
f. Uric acid with urates of ammonia f lime, and phosphate	Uric acid		
	Oxalate of lime		
	Ditto	Uric acid	
	Ditto	Ditto	Earthy phosphates
	Ditto	Earthy phosphates	
	Ditto	Phosphate of lime	Oxalate of lime an urate of ammonia
	Uric acid		
	Ditto	Earthy phosphates	
	Phosphate of lime		
	Ditto	Urate of ammonia	
[illegible]	Earthy phosphates		
Urate of ammonia with oxalate of lime	Earthy phosphates and uric acid		
Urate of soda	Uric acid		
Urate of lime	Uric acid with oxalate of lime and urate of ammonia		
Uric acid and urate of lime	Oxalate of lime		
Urate and oxalate of lime	Oxalate of lime and uric acid, alternating		
Urate of lime and urate of ammonia	Urate of lime and urate of ammonia, alternating		
Urate of lime and uric acid	Urate of lime		
Ditto	Earthy phosphates		

Urate of lime, urate of ammonia, and oxalate of lime	Phosphates			..	..	..	..	..	..	..	..	..	2	
Cystin				..	1	2	..	..	..	2	..	1	..	2
Phosphate of lime				12	3	2	4	4	4	1	..	..	2	4
Ditto	Earthy phosphates			..	..	2								
Phosphate of lime with oxalate of do.				..	..	1								
Ditto . with carbonate of do.				..	..	4	..	..	..	..	1	..	1	
Ammoniaco-magnesian phosphate				..	2	1	..	..	..	1	..	..	14	1
Ditto	Oxalate of lime			..	..	1								
Ammoniaco-magnesian phosphate with oxalate of lime				..	..	1								
Ammoniaco-magnesian phosphate and phosphate of lime	Earthy phosphates			..	..	..	..	..	..	..	..	1	2	
Earthy phosphates				..	24	5	37	49	..	18	7	..	..	13
Ditto	Oxalate of lime			..	..	1	..	2						
Ditto	Uric acid			..	..	..	..	1						
Ditto	Phosphate of lime			..	..	..	2							
Earthy phosphates with uric acid				66	..	9	..	..	18					
Carbonate of lime				..	..	2								
Laminated calculi of unknown composition				..	6	..	..	..	..	10				
Mixed calculi				..	7	..	..	2	8	6	..	..	..	8
Oxalate of lime, oxalate of magnesia, ammoniaco-magnesian phosphate, and phosphate of lime				..	..	..	..	..	..	..	..	1	1	
Urate of ammonia	Oxalate of lime	Urate of ammonia		..	..	..	..	..	..	..	..	..	..	1
Oxalate of lime	Uric acid	Oxalate of lime		..	..	..	..	..	..	..	..	..	..	1
Silica				..	..	..	..	..	..	..	..	..	1	
Silica with carbonate of lime				..	..	..	..	..	..	..	..	..	1	
				150	87	167	329	181	187	218	81	20	160	129

I now proceed to give one or two analyses of human calculi as illustrations of their general character.

I analysed the remarkable calculus alluded to in pp. 439 and 449. I examined, 1st, the external layer; 2d, the inner, tuberculated nucleus; and 3d, the minute round nucleolus. I have likewise analysed (4th) a calculus of uric acid.

	Anal. 160. Cortex.	An. 161. Nucleus.	An. 162. Nucleolus.	An. 163. Uric acid calculus.
Water	24·5	10·0	3·7	3·0
Solid residue	75·5	90·0	96·3	97·0
Earthy phosphates	70·5	1·1	—	—
Oxalate of lime	—	76·1	—	—
Uric acid	—	—	91·2	92·8
Alkaline urates	1·0	0·5	1·3	3·2
Animal matter	3·5	12·8	3·5	—
Fat and extractive matter	a trace	a trace	—	1·0

The animal matter in the cortex contained a little silica and peroxide of iron; and in the nucleus, a large quantity of dark brown colouring matter.

Uric acid calculi contain:

	According to				
	Taylor.	Joss.	Laugier.	Von Bibra. 1.	Von Bibra. 2.
Uric acid	60·0	70·0	10·0	84·69	96·10
Urate of ammonia	—	—	40·0	9·03	—
Urate of lime	—	10·3	—	—	—
Phosphate of lime	10·0	—	—	—	—
Ammoniaco-magnesian phosphate	20·0	—	—	1·12	—
Phosphate of ammonia	—	—	5·0	—	—
Oxalate of lime	—	—	15·0	0·95	—
Ammoniacal matter and water	10·0	19·0	20·0	1·80	1·60
A substance soluble in ether	—	0·5	—	0·81	0·50
" " alcohol	—	—	—	—	0·41

Calculi in which the earthy phosphates and carbonates predominate have been analysed by Fromherz and Lindberson:

Fromherz.	
Carbonate of lime	91·0
Phosphate of lime	3·0
Albumen and fat	4·0

Lindberson.	
Urate of soda	9·77
Basic phosphate of lime	34·74
Ammoniaco-magnesian phosphate	38·35
Carbonate of lime	3·14
Carbonate of magnesia	2·55
Albumen	6·87

[Calculi in which oxalate of lime predominates have been analysed by Scharling:

	1.	2.
Oxalate of lime . .	37	63·5
Phosphate of lime . .	—	6·2
Ammoniaco-magnesian phosphate .	39	—
Water . . .	10	30·3
Organic matters . .	13	

See also analysis 161, and the above analysis of Laugier.]

Cystic calculi have been analysed by Taylor and Bley:

	Taylor.	Bley.	
Cystin	10·0	6·2	—
Ammoniaco-magnesian phosphate .	10·0	36·6	75·0
Phosphate of lime . .	38·0	—	7·0
Carbonate of magnesia . .	—	57·1	—
Uric acid . . .	—	—	18·0
Animal matter and loss . .	42·0	—	—

Both the calculi analysed by Bley were taken from the bladder of the same man; the first weighed 1·75, and the second 2 grains.

URINARY GRAVEL.

Gravel has naturally the same composition as calculi; uric acid is, however, the most frequent constituent. In form, gravel is round or angular, not unfrequently crystalline; its colour is most commonly red, but sometimes pale yellow, gray, or brown. The rules already given for the analysis of calculi apply equally to gravel. After having ascertained by the blow-pipe whether the gravel is perfectly destroyed by heat, or whether it leaves an ash that burns white, we then proceed in accordance with the directions given in p. 431. Uric-acid gravel is frequently crystalline, and red or purple, but occasionally of a bright yellow colour, or white. The urine from which it separates is concentrated, highly coloured, and has usually a strong acid reaction.

White gravel is usually composed of phosphate of lime with ammoniaco-magnesian phosphate, and occasionally of oxalate of lime. The ammoniaco-magnesian phosphate crystallizes in beautifully regular prisms, (often of considerable size,) as de-

picted in fig. 25, and the oxalate in minute globules, or in octohedra, as represented in fig. 36. Phosphate of lime and ammoniaco-magnesian phosphate almost always occur together; oxalate of lime sometimes occurs by itself, and sometimes alternates with the earthy phosphates. Gravel consisting principally of the earthy phosphates is sometimes mixed with urate of ammonia, which latter readily dissolves when heated in water.

I have alluded to the analysis of this kind of gravel in my remarks on urinary sediments in p. 181. The urine in which this white earthy gravel is formed, is either neutral or alkaline, never acid.

Magendie describes a species of gravel containing hairs, (gravelle pileuse), consisting of phosphate of lime, ammoniaco-magnesian phosphate, and a little uric acid. It is possible that the hair may have been introduced from without, and thus be a mere accidental constituent. When cystin occurs as gravel, it almost always assumes the regular crystalline form that is so characteristic of that substance. Cystic gravel is of a yellow colour, and appears crystalline even to the naked eye.

Lecanu[1] analysed Segala's collection of 110 specimens of gravel. Seventy-nine of them (passed by 20 patients) consisted of uric acid with traces of ammonia and organic matter, which, however, in five cases were found only in the cortex, the nucleus consisting of pure uric acid. One minute calculus passed at the same time with others of pure uric, had a nucleus of oxalate of lime, and a thick cortex of uric acid. Five calculi from different patients, consisted of oxalate of lime without earthy phosphates, but with some uric acid; nine from different patients consisted of oxalate of lime and earthy phosphates; three from two patients consisted of phosphate of lime and ammoniaco-magnesian phosphate, without uric acid; four from the same patient consisted only of earthy phosphates; four from two patients consisted of ammoniaco-magnesian phosphate, without any appreciable traces of lime; three from two patients, of cystin. A calculus, the size of a pea, discharged with uric acid gravel from a man aged 62 years, was soft and white, soluble in water and alcohol, fusible, when heated evolving an odour of burned sugar, and containing a brown nucleus, formed

[1] Journal de Pharmacie, Sept. 1838.

apparently of a grain of corn. No cases of carbonate of lime were observed in this collection.

[Schlossberger has recently directed attention to the frequent occurrence of gravel (urate of ammonia) in the tubuli uriniferi of new-born children. He found it in 18 out of 49 cases.]

Preputial and urethral calculi have been analysed by Romer: fifty-one concretions of this sort, weighing in all 158 grains, were removed from a child with natural phymosis. They consisted of uric acid, associated with phosphate of lime and some connecting animal matter.

URINARY CALCULI OF ANIMALS.

Calculi are by no means uncommon amongst the lower animals, and it has been stated that rats are especially liable to this form of disease. Generally speaking the constituents are much the same as in man, except that no uric acid occurs in the calculi of the herbivora, which consist for the most part of earthy phosphates and carbonates.

In a wild cat, Fourcroy and Vauquelin found a renal calculus of phosphate of lime. The vesical calculi of dogs consist for the most part of phosphate of lime and ammoniaco-magnesian phosphate, with a little animal matter. (Marcet, Brande, Wollaston, and Prevost.) Brande found 30 parts of ammoniaco-magnesian phosphate, 64 of phosphate of lime, and 6 of animal matter. Lassaigne found 53 parts of oxalate of lime, 13 of phosphate of lime, and 39 of animal matter: in another calculus he found $97\frac{5}{8}$ of cystin. Two urinary concretions from these animals, examined by myself, were white and somewhat crystalline; they consisted principally of phosphate of lime with a little carbonate of lime. In a renal calculus from a dog, Lassaigne found 58·0 parts of uric acid, 30·8 of urate of ammonia, 1·1 of oxalate of lime, and 10·1 of phosphate of lime. Calculi from rats consist, according to Marcet, of ammoniaco-magnesian phosphate and phosphate of lime; according to Fourcroy, of oxalate of lime; and, according to Morand, of phosphate, carbonate, and oxalate of lime. Vesical calculi of

hares consist, according to Marcet and Brande, of phosphate and carbonate of lime. Vesical calculi of swine consist chiefly of carbonate and phosphate of lime, and ammoniaco-magnesian phosphate; according to Yellowly also, of oxalate of lime. The renal calculi of horses consist of carbonate and phosphate of lime in very variable proportions; Gurlt found 92·0% of the former, and 0·9% of the latter; while Brande found 22% of the former, and 76% of the latter: their vesical calculi are composed, according to Brande and Marcet, of the same constituents: a specimen, analysed by Buchholz, likewise contained ammoniaco-magnesian phosphate, silica, sulphate of lime, and carbonate of magnesia: a calculus, analysed by Wackenroder, contained 72·47 parts of carbonate of lime, 3·52 of carbonate of magnesia, 3·25 of sulphate of lime, 1·91 of phosphate of lime, 17·10 of mucus, and 1·40 of water. Vesical and renal calculi of oxen consist, according to Rapp, Brande, and Gmelin, of carbonate of lime. A calculus, analysed by Wurzer, contained 81·4 parts of carbonate of lime, 6·2 of phosphate of lime, 4·3 of carbonate of magnesia, ·009 of peroxide of iron, and ·001 of peroxide of manganese. The same chemist found in a calculus taken from the urethra of an ox, 60 parts of carbonate and phosphate of lime, 38·2 of silica, and 1·8 of peroxide of iron. In a very hard concretion taken from the urethra of an ox, I found a large proportion of carbonate of lime, mixed with a little phosphate of lime and silica.

[The following analyses have lately been made by Von Bibra:

	Calculi from ureter of a horse.	Calculus from bladder of swine.		
		1.	2.	3.
Carbonate of lime	87·63	78·81	—	—
Carbonate of magnesia	—	9·31	—	—
Ammoniaco-magnesian phosphate	6·61	—	93·27	90·41
Phosphate of lime	—	—	2·10	6·31
Sulphate of lime	1·64	—	—	—
Phosphate of magnesia	—	0·90	—	—
Organic matter taken up by potash	0·20	—	0·10	0·20[1]
" " alcohol	—	0·30	—	—
Fat	0·30	0·21	0·20	—
Water and loss	1·62	10·47	4·33	3·09

[1] Uric acid was taken up by the potash in this instance.

	Calculus from bladder of ox.	Do. from urethra of ox.
Carbonate of lime .	61·66	64·6
Carbonate of magnesia .	30·78	28·3
Fat . . .	0·80	0·2
Water, loss, and traces of iron	6·76	6·9

Lassaigne, who as far back as the year 1828 published a memoir on the calculi occurring in the dog, has recently detected a very singular specimen of concretion found in the kidneys, ureters, and bladder of a mastiff-bitch that died from dropsy. The calculi were irregular in shape and of a beautiful grass-green colour. They contained:

Urate of ammonia . . .	87·9
Green bile-pigment . .	12·1
Phosphate of lime . . .	a trace.

These calculi are not only remarkable for having uric acid as a constituent—a thing of rare occurrence in those animals, but for having associated with it a principle peculiar to the bile.[1]]

Concretions are likewise found in fishes, especially in the sturgeon; they are usually somewhat flattened, and marked with depressions; externally they are of a dull yellow colour; internally they are nearly colourless, and the section exhibits a concentric, radiating, and beautifully crystalline arrangement. Klaproth[2] analysed a concretion of this nature weighing seven ounces; it burned to a white ash before the blowpipe, and

[1] Bulletin de l'Académie de Médecine, Dec. 1842.

[2] [Wöhler has recently analysed a portion of a similar, if not the identical concretion. In 100 parts he found:

		According to $CaO, PO_5 + 5HO$.
Phosphoric acid . .	41·34	41·57
Lime . . .	31·66	32·48
Water . . .	26·26	25·95
Organic matter . .	0.74	—

Hence this concretion consists of the neutral phosphate of lime with five atoms of water, or $CaO, PO_5 + 5HO$, whereas common bone earth is $2CaO, HO, PO_5 + 2(3CaO, PO_5)$. Wöhler suggests the probability of this salt occurring in the place of ordinary bone-earth in the bones of these fishes.]

ultimately fused; it dissolved in nitric acid without effervescence, and contained 71·5 parts of phosphate of lime, 0·5 of sulphate of lime, 2·0 of albumen, and 24·0 of water. In an urinary calculus from a boa constrictor, Wurzer found 40 parts of uric acid, 18 of urate of ammonia, 9 of urate of soda, 19 of phosphate of lime, 10 of albumen, 3 of organic matter, and 1 of iron with traces of manganese.

Intestinal Concretions in Man.

From the researches of Dr. Jäger,[1] it appears that intestinal concretions (which are of much rarer occurrence than urinary calculi) consist of earthy phosphates and fatty matters. In conducting an analysis of an intestinal concretion, we proceed in much the same manner as in the case of a fixed urinary calculus. If cholesterin is present, the concretion must be extracted with ether, which, on evaporation, leaves that constituent mixed probably with other fats; to obtain it in a state of purity we must saponify the other fats with potash, remove them with water, and dissolve the residual cholesterin in boiling alcohol, from which it separates almost entirely on cooling. The other fats may be extracted by decomposing their soaps with hydrochloric acid, and collecting the liberated fatty acids. If bilifellinic acid is present, it may be extracted with alcohol after the fats have been removed by ether, and it may be separated after evaporation of the alcohol by digestion with dilute sulphuric acid. Boiling water will take up extractive matter, traces of chloride of sodium, chloride of calcium, and possibly urate of ammonia, a salt once observed by Brugnatelli in intestinal concretions passed in large quantity by a woman. When various organic matters, as for instance woody fibre, hair, &c. occur in these concretions, the earthy constituents must be dissolved in dilute hydrochloric acid, which leaves these organic matters unaffected.

Intestinal concretions are usually round or oval, but when several occur together their rounded form is often destroyed. In size they vary extremely; Renton describes one weighing four pounds, but from two to four ounces appears the ordi-

[1] Ueber die Darmsteine des Menschen u. d. Thiere, Berl. 1834.

nary weight. In colour they are most commonly yellow, but sometimes more or less gray or brown. Internally they present a laminated appearance like that of the earthy-phosphate calculi, or assume a radiating character, when they contain woody fibre or hair. Their nucleus is usually a foreign body, a fruitstone, a splinter of bone, a needle, or woody fibre. Children describes a calculus that was formed in the colon, round a plum-stone as a nucleus. It contained phosphate of lime 45·34, ammoniaco-magnesian phosphate 5·16, carbonate of lime 25·20, resinous matter 3·90, woody fibre 20·30. It likewise contained traces of hydrochloric and sulphuric acids. The cortex of another incrusted plum-stone contained phosphate of lime, albuminous matter, fat, and a sulphur compound.

An intestinal concretion examined by Davy consisted of ammoniaco-magnesian phosphate, phosphate of lime, carbonate and sulphate of lime with traces of silica 56; fibrous matter 41; animal matter 2·5.

A concretion found in the intestines of a boy who had taken carbonate of magnesia for a long period continuously, contained no nucleus, neither did it present the ordinary laminated appearance; it consisted entirely of magnesia.

The flattened concretions found by Schönlein in the intestinal ulcers of a patient with enterophthisis consisted, according to Kastner, of phosphate of lime, urate of ammonia, and animal matter.

Fatty matters combined with earthy phosphates are sometimes discharged in large quantities: hard concretions of this nature, varying from the size of a pea to that of a musket-ball, somewhat compressed, smooth, of a yellow waxy appearance, and internally white and horny, were passed by a phthisical girl, and consisted, according to Lassaigne, of 74 parts of acid fatty matters, margarin and olein, 21 of a substance resembling fibrin, 4 of phosphate of lime, and 1 of chloride of sodium: a similar mass analysed by Robiquet contained 60 parts of a fatty matter resembling spermaceti, 30 parts of phosphate of lime, and 8 of animal matter. I have likewise had opportunities of examining substances of this nature discharged by the rectum, but they were soft, and had a caseous appearance. They formed irregular, whitish, easily compressible, greasy masses; contained a large quantity of acid fat (margarin, olein, butyrin, and fibrous

matter;) and left a large amount of ash, consisting for the most part of phosphate of lime. (See p. 385.)

Calculi consisting of cholesterin with biliary resin and colouring matter are sometimes passed from the intestines, but as they must have had their origin in the gall-bladder, they will be considered under the head of biliary concretions.

Davy has found in intestinal concretions a large amount of fibrous matter; in one instance it amounted to 78%, combined with 21·5% of saline matter, and 0·5% of yellow pigment. In another case it amounted to 74·4%, and was associated with 17·2% of resinous matter, 1·4% of brown fæcal matter, and 7% of salts.

Laugier has observed hair in these concretions, matted together so as to form thick pilous masses.

[An essay on this subject by Dr. Douglas Maclagan, containing several original analyses, and published in vol. i of 'The Edinburgh Monthly Journal of Medical Science,' may be consulted with advantage.]

Intestinal Concretions in Animals.

Intestinal concretions are by no means rare either in the carnivora or herbivora; they seem to be especially common in horses. They consist principally of the most insoluble salts that occur in the food, which, instead of being uniformly distributed throughout the whole of the chyle, are collected at particular points, or else after having been dissolved in the stomach, are precipitated in the small intestines by the free alkali of the bile, and settle around any nucleus they may meet with. The principal constituents of intestinal concretions are phosphate of lime, phosphate of magnesia, ammoniaco-magnesian phosphate, and occasionally the carbonates of lime and magnesia. Gurlt[1] remarks that the reddish gray concretions found in the stomachs of horses sometimes attain a very considerable size; (he mentions a case in which a concretion weighed 14 pounds;) they consist of concentric laminæ, and are very hard. In horses they have occasionally a bluish-gray tint.

I have analysed a concretion taken from the cæcum of a

[1] Patholog. Anatomie der Haussäugethiere, p. 35.

cart-horse; it was round, perfectly smooth, of a grayish-yellow colour, weighed about 12½ ounces, was 3 inches and 7 lines in diameter, 11 inches in circumference, and consisted of 3 strata which were deposited round a fragment of granite. All three laminæ were composed of ammoniaco-magnesian phosphate with a little of the alkaline phosphates, but without any phosphate of lime. The second lamina had a radiating structure, and between the rays woody fibres might be detected. The central portion, about the size of a walnut, presented the appearance of a brown urinary calculus; the outer layer closely resembled common jasper. An analysis yielded:

	Analysis 164.
Ammoniaco-magnesian phosphate	81·11
Phosphates of potash and soda	1·50
Sand	0·60
Vegetable fibre	0·58
Alcohol-extract	0·50
Water-extract	0·50
Water and loss	15·19

I have analysed some of the concretions in the museum of the Berlin Veterinary College. Some small, flat, reniform, grayish brown concretions from the colon of a horse consisted chiefly of pure ammoniaco-magnesian phosphate aggregated around very minute nuclei of metallic lead. A flat, grayish brown concretion, of the size of a pigeon's egg, taken from the colon of a horse, contained, in addition, some phosphate of lime; the nucleus was a fragment of brick. The external layer of a gastric concretion from a horse, weighing 8 pounds, consisted principally of ammoniaco-magnesian phosphate combined with some phosphate of lime, and the external layer of a large calculus found in the intestines had a perfectly similar composition. Some small, triangular, smooth and white concretions from the stomach of a Dutch mastiff, when fractured, presented a beautiful, white, sparkling, crystalline character, and were composed of the same constituents; the quantity of phosphate of lime was, however, very small. The external layer of an intestinal concretion from an ass exhibited white and chalky lamellæ, with little firmness. It consisted of carbonate of lime, with a small admixture of phosphate of lime.

Carbonate of lime, such as I observed in the concretion

from the urethra of an ox, and in the above mentioned intestinal concretion from an ass, has been very rarely observed; Pearson detected it in a gastric calculus from an ape; Kinast in a similar concretion from a cow; Pearson and John in the intestinal concretion of a horse; and Vauquelin and Fourcroy in bezoars. Uric acid was observed by Fourcroy in the intestinal concretion of a horse.

Concretions formed of agglomerated hairs are often observed, especially in cows. They are usually brown and polished, but not hard.

[Several analyses of intestinal concretions have been recently published by Von Bibra.[1] We give the two following as illustrations of their composition:

	Concretion from intestines of horse.
Ammoniaco-magnesian phosphate	93·10
Phosphate of lime	1·18
Matters taken up by alcohol and ether	0·43
„ potash	0·36
Chloride of sodium	0·63
Phosphate of soda	0·31
Water, vegetable fibre, traces of iron, and loss	3·99

	Concretion from stomach of a miller's horse.
Ammoniaco-magnesian phosphate	93·02
Phosphate of lime	1·01
Matter taken up by alcohol	0·41
„ by potash	0·33
Sand	0·40
Chloride of sodium and traces of phosphate of soda	0·51
Water, traces of iron, vegetable fibre, and loss	4·32

The occurrence of phosphate of soda is remarkable, as that salt does not occur in the gastric juice.]

Peculiar concretions are found in the intestinal canal of an herbivorous animal inhabiting Persia and Thibet. They are termed bezoar stones; they are round or oval; in colour they are dark green, brown, or black; they are polished on the surface, and consist internally of concentric laminæ. Some are soluble, others insoluble in alcohol, but all dissolve in caustic potash. The researches hitherto made with these concretions throw very little light on their real composition. They are usually green

[1] Simon's Beiträge, pp. 404 12.

in the interior, do not fuse on being heated, and give off a not disagreeable odour. Hot water extracts a yellow matter; caustic potash dissolves them rapidly, forming a grayish brown solution, from which a dull green precipitate is thrown down on the addition of an acid.

This precipitate dissolves in nitric acid, producing a red tint, which rapidly changes to a yellow. Berzelius is of opinion that the principal mass of bezoar consists of biliary fat and resin, mixed with other fatty matter, and held together by intestinal mucus.[1]

Gall-stones in Man.

Biliary concretions are of very common occurrence in the human subject. They consist principally of cholesterin with a small amount of other fats, bilifellinic acid or biliary resin mixed with some bile-pigment, and mucus. In analysing a gall-stone, we first reduce it to a fine powder, which is a matter of no difficulty, and heat it on the water-bath in order to expel all moisture. The powder is then extracted with water, which takes up bilin with bilifellinic acid, and probably a little extractive matter; these are obtained by evaporating the water. The portion not taken up by water must be again dried and treated with hot, pure ether, which extracts the fat. We evaporate the ether, and dissolve the residue in hot alcohol, from which cholesterin crystallizes on cooling; after the removal of the cholesterin the evaporated alcohol yields the other fats as fatty acids. The residue insoluble in ether is now extracted with boiling anhydrous alcohol, which dissolves the biliary resin. On evaporating the alcoholic solution and treating the residue with cold alcohol, we obtain a solution of biliary resin (fellinic and cholinic acids, and dyslysin.)

The portion unacted on by alcohol may still contain biliphæin and biliary mucus; the former is soluble in carbonate of ammonia, the latter in a solution of potash.

Human gall-stones vary from the size of a hemp-seed to that of a pigeon's egg; they are round, or, if several occur together, angular and flat-sided, each facette lying in close apposition with that of the adjacent calculus. Their surface is smooth,

[1] [For further information on this subject the reader is referred to a paper by Guibourt, in vol. 16 of the 'Comptes Rendus,' and to observations 'on a new organic acid in benzoar stones,' by Lipowitz, in Simon's Beiträge, p. 462.]

their colour brown or yellow. Internally they present a decidedly crystalline character, they are white or yellow, and often contain a minute cavity in the centre, of a darker colour than the rest of the concretion, and presenting an incrusted appearance.

Witting[1] found in a human gall-stone cholesterin 50; resin and colouring matter insoluble in ether 35; carbonate of lime 8, water 5.

The following analyses of human gall-stones were made by Glaube and Brande:

	Glaube.	Brande. 1.	Brande. 2.	Brande. 3.
Cholesterin . . .	56	81·25	69·76	81·77
Biliary resin . . .	8	3·12	5·66	3·83
Bile-pigment . . .	15	9·38	11·38	7·57
Albumen with mucus and salts extractable by water . .	—	—	—	3·83
Coagulated albumen . .	9	—	—	—
Biliary mucus . . .	12	6·25	13·20	—

In addition to the ordinary constituents Von Bibra[2] found 1·5% of alumina with iron, and 1·4% of carbonate of lime in a biliary calculus; and Witting, as I have already observed, detected a considerable amount of the latter constituent in a concretion of this nature. An extraordinary quantity of this earth was found by Bally and Henry in a gall-stone; it consisted of carbonate of lime with traces of carbonate of magnesia 72·70, phosphate of lime 13·51, mucus, with a little peroxide of iron and bile-pigment, 10·81.

[Schmidt and Wackenroder have recently published analyses of human biliary calculi, consisting principally of colouring matter. Archiv der Pharmacie, vol. 41, p. 291.]

Berzelius mentions another kind of gall-stone, consisting principally of carbon; at least it is insoluble in water, alcohol and ether, acid and alkaline fluids; when heated to redness in a retort, undergoes no alteration, but when burned in oxygen, after giving off slight traces of smoke, takes fire, and burns without flame or residue, with the formation of carbonic-acid gas.

I have recently examined a biliary calculus found in the gall-bladder of an officer who died from cerebral and spinal irritation, and incipient softening of the nervous tissue: in

[1] Archiv der Pharm. vol. 25, p. 292. [2] Journ. für prakt. Chemie, vol. 12, p. 311.

contradistinction to the general rule, it contained mere traces of cholesterin, and was principally composed of biliary resin, and modified colouring matter.

[Bertazzi[1] has recently announced the discovery of copper as a constant ingredient of gall-stones. He analysed fourteen of these concretions sent to him by Polli, and found it in every instance. The amount of copper seemed to stand in a direct ratio to the amount of bile-pigment in the calculus. Thus, on incinerating an almost black spongy-looking concretion, so large a quantity of copper was present in the ash, that an iron cylinder, nearly a line in diameter and four inches long, after immersion for a few seconds in a dilute acid solution of the residue, was entirely coated. When, on the other hand, merely the nucleus or the external layer contained pigment, the indications of the presence of copper were comparatively slight, and he is of opinion that perfectly white concretions are entirely devoid of this constituent. With the view of ascertaining whether copper could be detected in the bile, Bertazzi analysed the fluid collected from the gall-bladders of ten persons. He could not, however, detect any indications of the metal.

The above statement respecting the presence of copper in biliary calculi has been subsequently confirmed by Heller.[2]]

Biliary Concretions in Animals.

Biliary concretions are very common in cattle: Gurlt never observed them in horses, and only once detected a calculus of this nature in a dog. The biliary concretions of cattle differ considerably from those of man; they consist for the most part of biliary pigment and resin, with a little cholesterin. In analysing the biliary concretions of oxen we must pursue the method already described, but at the same time we must not overlook the circumstance that an independent (lithofellinic) acid has been noticed by Göbel as occurring in them, which is not found in human biliary calculi. It is soluble in boiling alcohol and crystallizes on cooling; on heating it fuses, becomes decomposed and burns. It is insoluble in acetic and hydrochloric

[1] Polli's Annali di Chimica. Milan. Juglio 1845, p. 32.

[2] Archiv für physiolog. und patholog. Chemie, vol. 2, p. 228.

acids, but dissolves in caustic potash, with which it forms a soap that develops an odour resembling amber. It separates from this soap in a crystalline form on the addition of an acid. These crystals are of a rhombic-prism form, dissolve in alcohol and ether but not in water, fuse at a high temperature, and combine with alkalies to form soaps, which are slightly soluble in water, but dissolve readily in alcohol and ether. This acid has also been observed by Wöhler, and I have likewise detected a substance in the biliary calculi of cattle, which, as far as I have yet been able to analyse it, seems to be identical with lithofellinic acid. It is probable that lithofellinic acid is of more frequent occurrence than has hitherto been supposed; it ought, therefore, to be sought for in all biliary calculi, more especially in those of cattle.

The biliary calculi of cattle vary from the size of a pea to that of a pigeon's egg; they may be easily pulverized, the powder varying in colour from a dull green to a clear brown, and possessing a decidedly bitter taste. On boiling the pulverized calculus with alcohol, the alcohol becomes coloured yellow or green, and leaves on evaporation a small quantity of biliary resin and cholesterin. The powder, after extraction with alcohol, yields to caustic ammonia or to its carbonate, a certain amount of its colouring matter, but not so much as is taken up by an even very dilute solution of caustic potash. The alkaline solution is of a yellowish brown tint, but soon changes into a green. On the addition of hydrochloric acid to the alkaline solution the colouring matter is precipitated in the form of gray flocculi which dissolve readily in alcohol, leaving in an insoluble state the mucus that had been dissolved by the potash.

Schübler and Michel[1] analysed a concretion found in a cystic tumour in the liver of a man. It was of a red colour, and was composed of 25 parts of yellow, slightly saponifiable fat soluble in ether, and of 75 parts of red colouring matter. This colouring matter presented several remarkable characters, and Berzelius regards it as a morbid form of the ordinary bile-pigment.

[1] Journal für prakt. Chemie, vol. 8, p. 378.

Salivary Calculi, Tartar, &c.

In man salivary calculi are of rare occurrence, but the formation of tartar on the teeth is continually observed: it consists of earthy phosphates, epithelium-scales, a little ptyalin, and fat, and when examined under the microscope there are seen abundance of pavement epithelium and mucus-corpuscles with fat-vesicles, and, in addition to these, numerous long acicular bodies and infusoria of the genera Vibrio and Monas.

According to Berzelius tartar is composed of earthy phosphates 79·0, salivary mucus 12·5, ptyalin 1·0, animal matter soluble in hydrochloric acid 7·5.

Vauquelin and Laugier obtained similar results, namely, 66 parts of phosphate of lime with a little magnesia, 9 of carbonate of lime, 13 of salivary mucus, and 5 of animal matter soluble in hydrochloric acid.

Poggiale[1] analysed a salivary calculus taken from a man; it was hard, round, tuberculated, of a yellow colour, and easily pulverized. It contained a large amount (94$^0/_0$) of phosphate of lime, with a little mucus and animal matter.

Wurzer[2] analysed a calculus from the maxillary gland of a man; it weighed three grains, was oval, of a grayish white colour, and consisted principally of carbonate of lime and earthy phosphates, with traces of iron and manganese.

Salivary calculi are of frequent occurrence in the ass and the horse, and are occasionally found in the dog. They consist for the most part of earthy carbonates mixed with a small amount of earthy phosphates and animal matters.

The following analyses will give an idea of their composition:

	From an ass. Caventon.	From a horse. Lassaigne.	From a horse. Henry.
Carbonate of lime	91·6	84	85·52
Carbonate of magnesia	—	—	7·56
Phosphate of lime	4·8	3	4·40
Animal matter soluble in water	3·6	9	2·42
Water	—	3	—

Similar concretions occur in many other parts of the organism. I shall notice a few instances.

[1] Journal de Pharmacie, 1839, p. 337. [2] Archiv der Pharmacie, vol. 14, p. 254.

Wurzer analysed a concretion formed in one of the tonsils: externally it was of a grayish white colour, marked with rose-red spots, and verrucose; internally it presented no appearance of lamellæ, although it contained an oval nucleus. It consisted of phosphate of lime 63·8, carbonate of lime 16·7, animal matter 13·3, ptyalin, with chlorides of sodium and potassium, 7·1, iron and traces of manganese, 0·1. Daniel has described a hard and dense tumour, containing, however, traces of fibrous tissue, that occurred in the anterior wall of the uterus of a single woman aged 72 years. It contained 35% of animal matter and water, 56% of phosphates of lime and magnesia, 5% of carbonate of lime, and 4% of chloride of sodium and other salts. An earthy deposit in the uterus, analysed by Wiggers, contained 46·8% of earthy phosphates and carbonates, and 46·1% of fibrin, with a little fat. Poggiale has examined the muscular tissue of a man in whom ossification of the muscles had proceeded to such a length as almost entirely to prevent any voluntary motion. A portion of the ossified gastrocnemius contained 58% of organic matter, 32·09% of phosphate of lime, 1·25% of phosphate of magnesia, and 8·66% of carbonate of lime.

Concretions in the brain are very rare. I obtained a concretion of this nature that had formed in the cerebellum; it was about the size of a nut, of an irregular angular form, very solid, and both internally and externally resembled a portion of bone. The whole concretion was enveloped in a fine coriaceous capsule; it consisted principally of phosphate and carbonate of lime, with a little cholesterin. A similar concretion analysed by John consisted of 75 parts of the phosphates of lime and magnesia, and 25 of animal matter; another, examined by Morin, was composed of cholesterin, coagulated albumen, and earthy phosphates. In a concretion taken from the brain of a horse Lassaigne found 58 parts of cholesterin, 39·5 of coagulated albumen and cellular matter, and 2·5 of earthy phosphates.

[Scherer found in the gritty matter contained in the pineal gland:

Organic matter	22·460
Phosphate of lime	60·321
Carbonate of lime	17·219]

A concretion from the eye of a blind man contained, according to Wurzer, 47·9 parts of phosphate of lime, 9·5 of the carbonates of lime and magnesia, 20·3 of mucus, 0·9 of peroxide of iron, and 11·9 of clear fat resembling butter. A nasal concretion occurring in a woman aged 57 years was found by Brandes[1] to consist of 79·6 of phosphate of lime, 6·4 of carbonate of lime, and 14 of chloride of sodium, animal matter, and water. It consisted of five portions, weighing altogether 210 grains. It varied externally from a grayish white to a yellowish green colour, and its internal surface was gray and finely granular.

A nasal concretion analysed by Regnard consisted principally of carbonate of lime, with a little phosphate of lime and animal matter. A specimen analysed by Geiger consisted almost entirely of earthy phosphates and carbonates, while another examined by Herberger, yielded 46% of dried nasal mucus. A calculus of this nature weighing 81 grains, analysed by Römer, contained 90 parts of phosphate of lime, 5 of carbonate of lime, and 5 of animal matter with traces of carbonate of soda.[2]

Concretions formed in the lungs consist also principally of the earthy phosphates and carbonates. A pulmonary concretion analysed by Sgarzi, contained carbonate and phosphate of lime, carbonate of magnesia, cholesterin, fat, mucus, albumen, peroxide of iron, and silica. A concretion of this nature, that had been expectorated, was analysed by Brandes; it contained the above mentioned salts, cemented with mucus and albumen.

On examining the lungs of the boy with the osteoid tumour, noticed in p. 412, there was found in them an oval, solid encysted concretion, of the size of a hazel nut. Being anxious to ascertain whether it was allied to the osteoid tumour in its composition, I analysed it and found in 100 parts:

	Anal. 165.	In 100 parts of fixed salts.
Organic matter	38·89	
Fixed salts	61·11	
Earthy phosphates	53·33	87·20
Carbonate of lime	7·04	11·50
Soluble salts	0·37	0·65

[1] Archiv der Pharmacie, vol. 11, p. 157.

[2] [Much additional matter on the chemistry of nasal concretions may be found in a paper by Demarquay, in the 'Archives gén. de Médecine,' Juin 1845.]

Hence this concretion, in relation to the proportions of its salts, differs only in this respect from the osteoid tumour—that it contains a larger amount of carbonate of lime and a smaller quantity of soluble salts.

[A concretion found in one of the bronchi of a man who died from phthisis was analysed by Scherer. It had a knotty, white appearance, and was invested with a delicate membrane. It contained in 100 parts:

Organic matter	20·10
Phosphate of lime	69·92
Carbonate of lime	9·09
Chloride of sodium, sulphate and phosphate of soda	0·89

A hard concretion of the size of a pea, attached to the pleura, was analysed by Schierenberg, and found to contain:

Organic matter . . .	36·967
Phosphate of lime . . .	55·924
Carbonate of lime . . .	7·109]

A concretion in the pericardium, analysed by Petroz and Robinet, consisted of 65·3 parts of basic phosphate of lime, 6·5 of carbonate of magnesia, 4·0 of sulphate of soda, with a little sulphate of lime, and 24·3 of organic matter. Concretions in the mesenteric glands have been analysed by Wild: they contained 56-61% of phosphate of lime, 2% of carbonate of lime, and 26-28% of cellular membrane and fat. In a calcareous deposition on the peritoneum, Bley[1] found 34 parts of carbonate of lime, 27·66 of carbonate of magnesia, 10·32 of phosphate of lime, and 12·4 of albumen, mucus, and fat. A concretion from the prostate gland, examined by Lassaigne, contained 84·5% of phosphate of lime, with traces of carbonate of lime and animal matter.

I examined an incrustation occurring in the aorta of an old man who died from phthisis pulmonalis; it consisted principally of carbonate of lime and earthy phosphates.

[The ossified arterial membrane in the case of marasmus senilis, mentioned in p. 317 yielded, after careful preparation:

[1] Archiv de Pharmacie, vol. 20, p. 212.

Organic matter	7·292
Phosphate of lime	63·636
Phosphate of magnesia	10·909
Carbonate of lime	18·181]

Gouty concretions, which frequently form on the joints of the hands and feet, consist of urate of soda, with a little of the urates of potash and lime, chloride of sodium, and ordinary animal matter. Wollaston was the first to describe their composition correctly. The two following analyses will illustrate their composition:

	Laugier.[1]	Wurzer.
Uric acid	16·7	20·0
Soda	16·7	20·0
Lime	8·3	10·0
Chloride of sodium	16·7	18·0
Chloride of potassium	—	2·2
Animal matter	16·7	19·5
Water	8·3	10·3

Some gouty concretions, about the size of a pea, were analysed by Pauquy and Bor, and found to consist of urate of soda, urate of lime, and an albuminous substance, but no chlorides.

[In page 408 there is an analysis of bone in a case of arthritis, by Marchand. The same chemist analysed a gouty concretion on the lower articulation of the femur. It contained:

Urate of soda	34·20
Urate of lime	2·12
Carbonate of ammonia	7·86
Chloride of sodium	14·12
Water	6·80
Animal matter	32·53

Lehmann analysed a tophaceous concretion that formed on the metacarpus of a man only 22 years old, but who had suffered from well-marked gout. It was, on its removal, soft and tough, white internally, and reddish-brown on its external surface. When dried, it formed a white chalky mass. Under the microscope there were seen innumerable foursided prisms

[1] The loss in this analysis amounts to 16·6.

arranged in stellar groups; these consisted of urate of soda. The concretion, when dried, was found to contain:

Urate of soda	52·12
Urate of lime	1·25
Chloride of sodium	9·84
Phosphate of lime	4·32
Cellular tissue	28·49
Water and loss	3·88

A concretion of this nature, analysed by L'Heretier, yielded:

Urates of ammonia, soda, and lime	49
Phosphate of lime	42
Organic matter and water	9]

Tubercle.

Chemical analysis has hitherto thrown very little light on the nature of tubercle, or on the mode of its formation. A tubercular mass, analysed by Preus, contained 19·5 of solid constituents and 80·5 of water. The solid constituents were composed of a substance resembling casein in its relations towards acetic acid and heat, a fat containing cholesterin, and a very small quantity of salts.

In an analysis which I instituted of a mass of tubercle from a horse, I detected a little of the caseous matter noticed by Preus. The tubercular matter was deposited in masses from the size of a nut to that of a pigeon's egg; it varied from a yellow to a flesh colour, and its consistence was such as to admit of its ready division by the knife. Internally it was green and resembled coagulated casein. It was composed of:

	Analysis 166.
Water	84·27
Fat containing cholesterin	1·40
Spirit-extract with salts	1·52
Caseous matter with water-extract	1·14
Water-extract and salts	3·80
Insoluble constituents	4·44

[The following ultimate analyses of tubercle, by Scherer, are highly important in tending to throw light on the chemistry of its formation.

Crude pulmonary tubercle yielded little fat or extractive matter, showing that the morbid process was not far advanced.

An ultimate analysis, after the most careful removal of foreign constituents gave:

Carbon	53·888	which corresponds with the formula $C_{43} H_{35} N_6 O_{13}$
Hydrogen	7·112	
Nitrogen	17·237	
Oxygen	21·767	

Hence tubercle may be regarded as protein[1] ($C_{48} H_{36} N_6 O_{14}$), from which five atoms of carbon, one of hydrogen, and one of oxygen have been removed.

A mass of tubercle deposited in the liver, when examined under the microscope, was found to contain round, irregular, nucleated cells larger than pus-corpuscles, and numerous interspersed granules.

In 1000 parts there were contained:

Water	826·04
Solid residue	173·96
Fat taken up by ether, consisting of olein and margarin	18·63
Alcohol-extract	21·75
Water-extract with very slight traces of pyin	8·34
Insoluble organic residue	120·34
Fixed salts	4·90

This insoluble portion contained:

Carbon	54·554	which corresponds with the formula $C_{45} H_{36} N_6 O_{13}$
Hydrogen	7·121	
Nitrogen	16·928	
Oxygen	21·397	

Hence it may be supposed to be derived from protein that has lost three atoms of carbon and one of oxygen.

In tubercular masses found in the abdominal cavity, resembling coagulated albumen, there were found:

Water	893·82
Solid residue	106·18
Fat	25·40
Casein and alcohol-extract	12·39
Pyin and water-extract	6·19
Salts	7·43
Crude tubercular matter	54·55

which yielded in three analyses:

	1.	2.	3.
Carbon	55·299	55·069	55·137
Hydrogen	7·098	7·004	6·944
Nitrogen	16·698	16·534	16·476
Oxygen	20·905	21·393	21·443

[1] This is Liebig's formula.

These analyses correspond with the formula $C_{46}\ H_{36}\ N_6\ O_{13}$; hence tubercle in this case may be regarded as protein from which two atoms of carbon and one of oxygen have been removed.

In this instance, the surface of the liver was coated with a layer of plastic exudation a line and a half thick. This was separated and analysed in the same manner as the tubercular matter. It contained:

Water	731·62
Solid constituents . . .	268·38
Fat	15·47
Water-extract with pyin and casein .	4·32
Spirit-extract . . .	6·23
Salts	5·40
Insoluble organic residue . .	237·96
Containing—Carbon . .	55·190
Hydrogen . .	7·186
Nitrogen . .	16·602
Oxygen . .	21·022

This substance is consequently identical in its ultimate composition with the tubercular matter found in the abdomen.

Tubercular matter from the brain yielded, after purification:

Carbon . .	54·410	which corresponds with the formula $C_{46}\ H_{37}\ N_6\ O_{14}$
Hydrogen . .	7·147	
Nitrogen . .	16·366	
Oxygen . .	22·077	

That is to say, two atoms of carbon less, and one atom of hydrogen more than occurs in protein.

If in this and the preceding analyses the formulæ for the morbid deposits are calculated in relation to C_{48}, their connexion with the formula for protein will be more obvious to the eye. We shall have:

2 At. of tubercular matter from the lungs . $= 2\overline{Pr} + NH_3 + 2HO + H$
2 At. of tubercular matter from the liver . $= 2\overline{Pr} + NH_3 + H$
2 At. of tubercular matter from the abdomen $= 2\overline{Pr} + NH_3$
4 At. of cerebral tubercle . . $= 4\overline{Pr} + 2NH_3 + 4HO + 3H$

Scherer has adopted a similar course of research with other morbid products.

A scrofulous mass found in the abdomen of a child who died from general scrofula, was, after extraction with water, alcohol,

and ether, submitted to ultimate analysis. Independently of salts, it yielded:

Carbon	54·125	which corresponds with the formula $C_{46} H_{38} N_6 O_{12}$
Hydrogen	7·281	
Nitrogen	15·892	
Oxygen	22·702	

Hence the scrofulous matter may be regarded as formed from protein by the removal of two atoms of carbon and oxygen, and the addition of two of hydrogen, or making the amount of carbon the same in the scrofulous mass and the protein, we have:

$$1 \text{ At. scrofulous matter} = \overline{Pr} + HO + 2H.$$

Carcinoma uteri and scirrhus testiculi were examined by Scherer in a similar manner.

L'Heretier has made the three following proximate analyses of scirrhus:

	Of breast.	Of uterus.	Of dorsal region.
Water	29·75	21·15	24·80
Albumen	28·10	29·85	21·70
Fibrin	18·80	15·20	27·15
Gelatin	7·60	—	8·17
Fat	2·00	—	8·05
Phosphorized fat	—	6·00	—
Peroxide of iron	1·15	1·25	traces
Yellow pigment	—	7·00	—
Salts	12·60	9·55	10·13]

A fatty tumour analysed by Nees von Esenbeck[1] contained 23·0 of solid fat, 12·0 of extract of flesh, 11·0 of gum-like animal matter, 23·0 of albumen, 19·0 of phosphate of lime, 2·0 of carbonate of lime, and 1·5 of carbonate of magnesia. It is not stated whether this solid fat contained cholesterin; in all probability it did, as this fat is of frequent occurrence in fatty tumours. In a fatty tumour examined by J. Müller there were acicular crystals mixed with a gray substance which was deposited in vesicles and dissolved in boiling water, from which it was not precipitated by acids or the ordinary metallic salts. The crystals were insoluble in acids, water, or alcohol, but dissolved in ether; hence they probably consisted of cholesterin.

[1] Kastner's Archiv, vol. 12, p. 460.

Another fatty tumour contained some casein precipitable from the aqueous solution by acetic acid.

Incrustations on the surface of the body.

Sore surfaces from which the epidermis has been removed are covered by a fluid which usually consists, according to Berzelius, of serum. This fluid dries up and protects the exposed surface from the atmospheric influence. My own investigations lead me to believe that this fluid differs materially from serum, that it contains a much larger quantity of albuminate of soda, and that its solid residue consists, for the most part, not of coagulated albumen, but of epithelium- and pus-cells.[1] Lassaigne has analysed the crusts of small-pox; they contained 63—70 parts of coagulated, and 15—14 of uncoagulated albumen, 2—1 of fat, 18—11 of extract of flesh, and 2—2·5 of salts. Wackenroder found uncoagulated albumen in the crusts of tinea capitis.

I have analysed the crusts which formed on sores on the body of a man with a severe attack of icterus. They appeared as yellow or whitish-yellow scales, or as large shreds of skin, and were very difficult to pulverize. When rubbed with water they swelled, and ultimately formed an emulsive sort of fluid, which did not clear on standing, and in which a very large number of epithelium-scales were suspended. The filtered fluid coagulated very slowly on the application of heat, but became covered with a film during evaporation. It had a faintly alkaline reaction, and was rendered slightly turbid by the addition of an acid, but again became clear on the addition of an excess of the test. It was strongly precipitated by ferrocyanide of potassium, infusion of galls, and bichloride of mercury. On heating the residue, after evaporation with water, it was found to be almost insoluble; alcohol took up some extractive matter with a very little chloride of sodium.

The residue yielded an ash which slightly effervesced on the addition of nitric acid, and contained mere traces of the earthy phosphates and chlorides, but a considerable amount of phos-

[1] [In connexion with this subject a paper 'On Pyinn, and its importance in the Human Organism,' by Eichholtz, in Rust's Mag. für die gesammte Heilkunde, vol. 64, p. 140, may be consulted with advantage.]

phate of soda. The portion insoluble in water appeared, when examined under the microscope, to consist of epithelium-cells, for the most part more or less injured. Alcohol took up from these scales a little yellow fat which partly separated on cooling: this portion consisted of margaric acid and margarin, while oleic acid remained in solution. The ash left by the direct incineration of the scales contained scarcely appreciable traces of sulphates or chlorides, a little carbonate and a large amount of phosphate of soda, earthy phosphates, and a trace of iron. Hence these scales contained the ordinary fats and fatty acids, a little uncoagulated albumen, a large quantity of albuminate of soda, some extract of flesh, and a considerable amount of salts, in which the phosphate of soda and earthy phosphates predominated. No bilin could be detected, and only a trace of bile-pigment.

I have recently examined the scales of a person with ichthyosis. They were of a gray or black colour; when placed in water they softened, and on then placing a section under the microscope I found that the abnormal structure was formed of compressed epithelium-scales.

On incineration the scales left an ash containing carbonate and phosphate of lime, and peroxide of iron; the latter was in such abundance as to communicate a yellow colour to the ash. The ash yielded by the incineration of the ordinary thickened skin on the hands and feet is perfectly white, and contains a mere trace of peroxide of iron.

CHAPTER XIII.

FLUID PRODUCTS OF DISEASE.

Hydatids are round vesicles filled with fluid, sometimes but not always containing a minute animal (echinococcus); these vesicles occur most commonly in the brain and liver. Göbel analysed hydatids from the liver of a goat; the echinococcus was present in large numbers; the fluid contained in the vesicles was clear, yellow, neutral, gave off an unpleasant odour during evaporation, and blackened a silver spatula with which it was stirred. It yielded 1·54% of solid residue consisting of ·04 albumen, 0·24 mucus, and 1·26 salts, namely, carbonate of soda, chloride of sodium, sulphate of potash, and phosphate of lime. The vesicle itself was insoluble in water and alcohol, yielded a little fat to ether, swelled in acetic acid without dissolving, but dissolved in a solution of caustic potash, from which it could be precipitated by the addition of acetic acid.

Collard de Martigny has likewise analysed hydatids. The fluid contained in them was faintly yellow, and somewhat turbid from the presence of flocculi of albumen, which soon settled to the bottom. Boiling produced a marked turbidity in consequence of the coagulation of albumen. It contained water 96·5, albumen 2·9, and salts, for the most part chloride of sodium, 0·6.

The membrane enclosing the fluid was divisible into five laminæ, was insoluble in ether, alcohol, and boiling water, but dissolved, even without the aid of heat, in sulphuric, hydrochloric, and nitric acids, from which it was not precipitated on neutralization with a free alkali; it was not dissolved by acetic acid, and was rendered leathery by infusion of galls.

[Scherer has analysed the fluid contained in hydatids of the kidney. It was of a brownish yellow colour, threw down a

light, flocculent, brown deposit, and evolved an ammoniacal odour.

In 1000 parts there were contained:

Water	934·762	
Solid constituents	65·238	
Albumen	15·960	Protein-compounds 26·006
Albuminate of soda	10·044	
Alcohol-extract with lactates & ammonia-salts	22·312	Transformed matters 28·351
Water-extract	3·797	
Fat	2·042	
Inorganic salts	10·615	
Uric acid	0·413	

Not a trace of urea could be found; it had probably been converted into carbonate of ammonia.]

Cysts may either be filled with a solid matter, as for instance, fat (in which case they form the fatty tumours of which we have already spoken), or they may contain a fluid.

Collard de Martigny analysed the fluid contents of a cystic tumour situated between the rectum and the uterus. The fluid was of the consistence of a syrup, of a dirty yellow colour, viscid, and of a sickly odour. When evaporated at a temperature of 104°, it left a brown residue amounting to 12·8%, which softened in water without dissolving, and on heating gave off an odour of burned horn. On the addition of alcohol to the fluid a thick, elastic, yellow mass was precipitated; which dissolved in water and was again thrown down on adding a dilute acid, but was soluble in an excess of the reagent. The alkalies, sulphate of iron, and nitrate of silver, exerted no influence on this solution, but a yellow precipitate was thrown down by nitrate of the protoxide of mercury, tincture of iodine, tannin, and bichloride of platinum. From these imperfect data it is impossible to form any conclusion regarding the true nature of the fluid.

I made an analysis of a thick chocolate-coloured, alkaline fluid, obtained by puncture in a case of ovarian dropsy. Under the microscope there were a considerable number of pus-corpuscles, and a few coloured blood-corpuscles visible. It con-

tained so much albumen that on heating it coagulated, forming thick brown flocculi. The colouring matter is doubtless to be attributed to the presence of hæmatoglobulin: the fat abounded in cholesterin.

It contained:

	Analysis 167.
Specific gravity	1030
Water	925·00
Solid constituents	75·00
Fat containing cholesterin	1·10
Albumen	56·77
Alcohol-extract, Spirit-extract, Water-extract	4·50
Carbonate of soda, phosphate of lime, chloride of sodium and lactate of soda	8·89
Albuminate of soda	7·50

[Scherer has made several analyses of the contents of ovarian cysts.

1. A thick, viscid fluid of this nature, obtained from a woman aged 40 years, had an alkaline reaction, a specific gravity of 1022, and when allowed to stand, deposited a sediment composed of granules, inflammatory globules, and minute nucleated cells.

In 1000 parts there were:

Water	952·2	
Solid constituents	47·8	
Protein-compounds thrown down by alcohol	33·6	
Extractive matters	9·1	
Salts	5·3	consisting chiefly (nearly 4·08) of chloride of sodium.

On a subsequent occasion (about two months afterwards) the fluid contained:

Water	940·90
Solid constituents	59·10
Albumen precipitable by boiling, after the addition of acetic acid	42·62
Extractive matters	12·03
Inorganic constituents	5·58

2. In another instance a fluid was obtained containing:

Water	867·57
Solid constituents	132·43
Mucin with exudation-cells	27·65
Albumen coagulated by boiling	55·70
Albuminate of soda	30·26
Fat	4·70
Alcohol-extract	3·52
Water-extract	2·35
Fixed salts	7·81

The mucin and exudation-cells were precipitated from the fluid by acetic acid; they were then boiled with alcohol in order to remove any adherent fat, and submitted to ultimate analysis

They yielded:

Carbon	55·443	A little more nitrogen and hydrogen, and rather less oxygen than protein.
Hydrogen	7·114	
Nitrogen	18·305	
Oxygen	19·138	

In the following analyses, 1 and 2 represent the composition of the contents of two other cysts in the same ovary, 3 represents the fluid in another case:

	1.	2.	3.
Water	903·11	839·904	799·85
Solid constituents	96·89	160·096	200·15
Albumen	40·38	150·534	—
Albuminate of soda	36·50		172·95
Fat	3·40	—	3·13
Extractive matters	6·07	1·456	14·50
Salts	8·54	8·006	10·43]

Valentin has analysed a tumour (meliceris) containing a fluid of the consistence of honey, of a dirty yellow colour, devoid of odour, and leaving on evaporation, 11·3% of solid residue, which consisted of, in 100 parts:

Coagulated albumen	52·49
Olein and oleate of soda	28·50
Cholesterin	3·12
Stearin	1·96
Uncoagulated albumen with a little potash	9·17
Lime	1·88
Magnesia	0·92

[The contents of a strumous cyst analysed by Scherer contained:

Water	920·54	
Solid constituents	79·46	
Albumen with a little blood	61·23	
Extractive matters	8·71	Transformed matters 10·51
Fat (chiefly cholesterin)	1·80	
Salts	7·72	]

Fluid of pemphigus. I have examined the faintly yellow fluid occurring in the bullæ of pemphigus. It had an acid reaction, and deposited a sediment of corpuscles resembling mucus- or pus-corpuscles in form, and in which a nucleus was very apparent. Its specific gravity was 1018. On evaporation it developed an acid odour similar to that which is observed on evaporating the saliva in cases of ptyalism and due to the presence of a little acetic acid. When submitted to a high temperature it deposited a quantity of very white albumen; the acid reaction was then more powerful than before, but after evaporation to dryness it disappeared, for the alcohol with which the residue was extracted had scarcely a perceptibly acid reaction. It was composed of:

	Analysis 168.
Water	940·0
Solid constituents	60·0
Fat containing cholesterin	2·6
Albumen with earthy phosphates	48·0
Extractive matter soluble in alcohol, with lactate of soda and chlorides of sodium and potassium	6·5
A substance resembling ptyalin, soluble in water	1·9
Free acetic acid and mucus-corpuscles	imponderable

Five years afterwards I examined the fluid from the same patient during a fresh attack. In its physical characters it was much as before.

It contained in 1000 parts:

	Analysis 169.
Water	959·8
Solid constituents	40·2
Albumen with mucus-corpuscles	28·1
Fat	3·0
Alcohol-extract	3·0
Fixed salts	4·5

The fluid was strongly acid from the presence of acetic acid; no indications of urea were detected.

[Girardin has recently made an analysis of the fluid in certain vesicles on the abdomen.

In 1000 parts there were contained:

Water	939·500
Solid constituents	60·500
Albumen	49·200
Cholesterin	6·475
Alcohol-extract	1·075
Phosphates of soda and lime, and chloride of sodium	3·750]

Fluid of hygroma. I have examined the fluid of an hygroma situated on the lower jaw of a horse. The fluid was almost clear and transparent, but so extremely viscid that it could be drawn out into long threads. Its reaction was alkaline. Under the microscope a few very large mucus-corpuscles, three or four times the ordinary size, could be observed, occurring as round granular vesicles, in which, in consequence of the opacity of the investing membrane, the nucleus could not be detected.

The fluid did not mix with water, but a separation of white flocculi took place; white gelatinous flocculi were likewise precipitated by alcohol. Ebullition rendered the fluid opaque, but did not altogether coagulate it.

The gelatinous mass precipitated by alcohol was boiled in spirit of ·848 and then warmed with water, in which it swelled and became viscid without dissolving. On the addition of acetic or hydrochloric acid to the swollen mass it coagulated immediately into opaque fibrils. It was perfectly soluble in a dilute solution of caustic potash with the aid of heat, and again precipitable by acetic acid, without being soluble in an excess of the reagent. Hydrochloric acid threw down a substance which was immediately redissolved, and a peculiar odour of sulphuretted hydrogen was evolved, just as when we add hydrochloric acid to an alkaline solution in which horn-shavings have been digested.

The hydrochloric-acid solution was scarcely rendered at all turbid by ferrocyanide of potassium, but was strongly precipitated by tannin. From these experiments it appeared that the substance under examination was mucin. Alcohol took up a very small quantity of chloride of sodium and lactate of soda

from this fluid. The mucin left, on incineration, an ash of phosphate of lime.

Dropsical fluids. The fluids that collect in different parts of the body, especially in the cavities of the abdomen and thorax, and in the subcutaneous cellular tissue, in a certain class of disorders (dropsies), have been frequently submitted to chemical analysis. Fluids of this nature are usually of a faint yellow colour, and more or less turbid; flocculi of coagulated fibrin are sometimes present, and occasionally, after acute inflammatory attacks, they contain so large an amount of that constituent as to assume a gelatinous consistence. Their specific gravity varies from 1010 to 1020 or higher; their reaction is alkaline, and they sometimes contain so small a quantity of albumen as only to be rendered slightly turbid by heating, while in other cases the amount is so large that the whole fluid becomes coagulated; the quantity of salts, especially of chloride of sodium, is frequently also considerable. If the kidneys are affected, urea is generally present. The fat usually contains cholesterin.

The following analyses of the fluid found in the brain in cases of hydrocephalus approximate closely in their results:

	Berzelius.	Mulder.	Marchand. 1.	Marchand. 2.
Water	988·30	989·997	986·54	989·93
Solid constituents	11·70	10·003	13·46	10·07
Albumen	1·66	0·549	1·10	1·02
Fat	—	0·070	0·05	0·33[1]
Alcohol-extract with lactate of soda	2·32	2·538	2·10	3·21
Water-extract	0·26	—	0·13	—
Chlorides of sodium and potassium	7·09	6·553	7·87	5·28
Earthy phosphates	0·09	0·090	0·10	0·23
Sulphate of soda	—	0·146	0·11	
Carbonate of soda	—	0·057		
Soda	0·28	—	—	—

Marcet obtained similar results in his analyses of dropsical fluids.

Marchand found an extraordinarily large amount of urea in the fluid, removed by tapping, from a woman with ascites.

[1] Of this, 0·21 was cholesterin.

There were contained in 1000 parts:

Water	952·2
Solid constituents	47·8
Albumen	23·8
Urea	4·2
Chloride of sodium	8·1
Carbonate of soda	2·1
Phosphate and traces of sulphate of soda	0·6
A viscid substance	8·9

[Several analyses of the fluid of ascites have been recently made, some of which we shall insert in a condensed form. The two following were made by Scherer:

1. A whitish turbid fluid removed from the abdomen by paracentesis, in a case of dropsy dependent on abscesses proceeding to chronic suppuration, yielded in 1000 parts:

Water	986·71
Solid residue	13·29
Minute granules and soluble albumen	3·61
Extractive matters	1·80
Salts	7·90

The fluid evolved no odour, and was neutral.

2. The fluid obtained by tapping a patient with dropsy from 'steatoma hepatis, carcinoma ventriculi, et perienteritis chronica,' was examined on two occasions:

	1.	2.
Water	952·99	960·49
Solid constituents	47·01	39·51
Fibrin	0·32	—
Albumen	11·88	—
Albuminate of soda	22·70	29·73
Extractive matters	3·02	2·12
Fat	1·26	1·63
Salts	7·22	5·94

Urea was sought for in analysis 1, but without success.

Heller analysed the dropsical effusion in the case of ascites noticed in p. 311.

The fluid had a milky appearance, was neutral, devoid of odour, and its specific gravity was 1007.

Nitric acid and heat scarcely affected it, but an enormous precipitate was thrown down by nitrate of silver.

In 1000 parts there were contained :

Water	950·00
Solid constituents	50·00
Extractive matters and traces of albumen	5·97
Fat	0·84
Fixed salts (almost exclusively chloride of sodium)	44·00

Not a trace of urea or of bile-pigment could be detected. The fat was perfectly saponifiable and contained no cholesterin. In addition to the enormous amount of chloride of sodium in the effusion, it was abundant in the urine (see page 312), and the sweat was so saturated with it that it crystallized in minute glittering particles on the skin.

In a case of Bright's disease, in which the walls of the abdomen were punctured, a fluid with an alkaline reaction and specific gravity 1007·5 was obtained. It was analysed by Heller, and found to contain :

Water	980·640
Solid constituents	19·360
Albumen	8·121
Free fat	0·220
A soda-soap	0·392
Extractive matters	2·546
Fixed salts	8·080

It yielded no indications of urea, bile-pigment, or cholesterin.

Percy found in a fluid of this nature :

Water	952·0
Solid constituents	48·0
Albumen	38·0
Indeterminate organic matter	3·2
Salts	7·6

I made an analysis of the dropsical fluid obtained by puncturing the abdomen of a young man in whom the subsequent autopsy revealed suppuration of both kidneys. Urea was present in this fluid, which was of a faintly yellow colour, strongly alkaline, and threw down flocculi of albumen on boiling.

It contained:

	Analysis 170.
Specific gravity . . .	1010
Water	978·0
Solid constituents . . .	12·0
Fat containing cholesterin . .	1·0
Albumen	8·4
Alcohol-extract . . .	0·3
Spirit-extract . . .	1·7
Carbonate of soda and phosphate of lime	1·2
Chloride of sodium and lactate of soda .	6·8
Urea	1·2

Thoracic effusions. I have analysed the fluid obtained from the cavity of the pleura by paracentesis thoracis. It was of a yellow colour, devoid of odour, and consisted of two portions, viz., a thin liquid portion and a gelatinous clot floating on it. The fluid had a strongly alkaline reaction, a specific gravity of 1022·4, and showed, under the microscope, a few primary cells of the size of pus- or mucus-corpuscles. The coagulum was slight in its consistence, and when examined microscopically was found to exhibit the structure of coagulated fibrin, with a few enclosed primary cells; when washed with water the fibrin was left perfectly white.

In 1000 parts there were contained:

	Anal. 171.
Water	934·72
Solid constituents . . .	63·28
Fibrin	1·02
Fat	1·05
Alcohol-extract with salts . .	1·35
Spirit-extract with salts . .	10·64
Albuminate of soda . .	17·86
Albumen . . .	31·00
Fixed salts . . .	9·50

The fluid, both in its physical and chemical characters, closely resembled lymph.

[The following analyses of similar fluids have been made by Scherer. In 1 and 2 the fluid was taken at an interval of eight days from the same person. In 3, it should be observed, that the fluid was not analysed till a fortnight after the operation.

	1.	2.	3.
Water	935·52	936·06	928·0
Solid constituents	64·48	63·94	72·0
Fibrin	0·62	0·60	—
Albuminate of soda	49·77	52·78	—
Albumen	—	—	52·0
Fat	2·14	1·35	2·4
Alcohol-extract	1·84	1·61	5·2
Water-extract	1·62		2·2
Salts	7·93	7·40	10·2]

I once analysed the fluid obtained from incisions in the lower extremities of a man with Bright's disease. It contained a very appreciable amount of urea, and a considerable quantity of albumen, with much chloride of sodium.

I give the results of this analysis:

	Analysis 172.
Specific gravity	1012
Water	976·0
Solid constituents	24·0
Fat containing cholesterin	0·5
Albumen	7·0
Alcohol-extract with urea	2·0
Spirit-extract	1·9
Water-extract	3·0
Carbonate of soda and phosphate of lime	1·0
Chloride of sodium and lactate of soda	8·1

[Heller has recently published an elaborate essay on the chemistry of the fluids in Bright's disease, including several analyses of the subcutaneous serum. His analyses of the blood and urine will be found in Appendix II.

a. The subcutaneous serum from the body of a man who died from Bright's disease was of a pale yellow colour, alkaline, and had a specific gravity of 1011. It contained only a very small quantity of albumen, but a large amount of fixed salts, viz. 10·1 in 1000 parts of the fluid.

b. Several ounces of fluid were obtained by incisions in the leg of a man aged 40 years, with general œdema. The liquid was clear and almost as colourless as water, there being merely a very faint tint of yellow. On cooling there was formed at the bottom of the vessel a very light and delicate clot, which was slightly pink from the presence of a few blood-corpuscles;

the serum was then entirely colourless, had an alkaline reaction and a specific gravity of 1010.

In 1000 parts there were:

Clot	18·78
Serum	981·22

And there were contained in the fluid:

Water	986·800
Solid constituents	13·200
Fibrin	0·134
Extractive matter, an imponderable quantity of albumen, and urea	4·226
Fixed salts	8·840

c. The serous fluid obtained in another case, by incisions in the leg, was turbid, of a dirty yellow colour, and deposited a flocculent sediment, consisting for the most part of epithelium-scales, with a little pus and a few crystals of ammoniaco-magnesian phosphate. The reaction was strongly alkaline, and the specific gravity 1010.

There were contained in 1000 parts:

Water	975·20
Solid constituents	24·80
Albumen	5·42
Extractive matters, salts, free and saponified fat, and urea	3·76
Fixed salts	15·62

We shall revert to this subject, in relation to the composition of the blood and urine, in the Appendix.]

I have analysed the fluid obtained from a hydrocele; it was remarkable for the large amount of cholesterin contained in it; it was of a yellow colour, devoid of odour, alkaline, and sparkled when shaken, in consequence of the numberless crystals of cholesterin suspended in it. The amount of solid constituents was larger than I have ever observed in any other serous fluid of a similar nature. The amount of salts, composed principally of chloride of sodium, is also very remarkable.

This fluid contained:

	Analysis 173.
Water	860·00
Solid constituents	140·00
Cholesterin with a little margarin and oleic acid	8·40
Albumen	48·30
Albuminate of soda with extractive matter	6·88
Extractive matter soluble in alcohol	2·30
Chlorides of sodium and calcium, a little sulphate, and traces of phosphate of lime	72·52
Phosphate of lime with traces of peroxide of iron	0·70

[Heller has recently published an essay on the fluid of hydrocele, founded on three analyses:

1. Nearly ten ounces of fluid were removed from a man aged 65 years, who had laboured under hydrocele for seven years.

The fluid was of a dark-brown colour, alkaline, and of specific gravity 1021.

It contained a large amount of bile-pigment but no cholesterin, and after standing deposited a sediment.

In 1000 parts there were contained:

Water	919·2
Solid constituents	80·8
Albumen	58·0
Free fat	1·6
A soda-soap, biliphæin, hæmatoglobulin, dissolved hæmatin, and extractive matters	13·9
Fixed salts	7·3

2. About three ounces were obtained from a man aged 30 years. The fluid was of a clear yellow colour, strongly alkaline, and had a specific gravity of 1020.

It contained in 1000 parts:

Water	934·00
Solid constituents	66·00
Albumen	52·81
Fixed salts, chiefly chloride of sodium	7·68
Fat, but no cholesterin	0·14
Water-extract	1·17
A soda-soap, biliary resin and pigment, urea, uric acid, and alcohol-extract	4·20

3. One ounce was taken from a man aged 50 years. It

was clear, of a dark yellow colour, alkaline, and had a specific gravity of 1020.

It contained in 1000 parts:

Water	906·36
Solid constituents	93·64
Albumen	60·00
Fat containing cholesterin	0·23
Extractive matters, biliphæin, and a soda-soap	24·04
Fixed salts, chiefly chloride of sodium	9·37

A specimen examined by Percy contained in 1000 parts:

Water	927·4
Solid constituents	72·6
Albumen	59·2
Fat taken up by ether	a trace
Alcohol-extract	1·2
Water-extract	2·2
Chloride of sodium with traces of chloride of potassium	6·0
Soda and lime, with sulphuric, phosphoric, and carbonic acids	4·0]

A matter obtained from the scrotum in another case of hydrocele was of a brown colour, hardly fluid, but rather of a pulpy consistence. Under the microscope[1] it was found to contain an immense number of crystals of cholesterin, numerous blood- and pus-corpuscles, and a yellow substance resembling coagulated albumen. On heating, it coagulated like blood; it yielded a large amount of cholesterin to ether, and of hæmatoglobulin to hot spirit.

[The following analyses by Scherer, of fluid effusions found in the body after death, are worthy of notice.

1. The fluid found in the abdominal cavity after death from scirrhous degeneration of the chylopoietic viscera, contained:—

[1] [According to Heller, on making a microscopic examination of the fluid of hydrocele, we may expect to find: 1, blood-corpuscles; 2, fragments of epithelium; 3, coagula of albumen or fibrin; 4, fat; 5, cholesterin; 6, globules of inflammation; 7, pus; and 8, occasionally spermatozoa.]

Water	963·39
Solid constituents	36·61
Albumen	12·82
Albuminate of soda and hæmatin	7·13
Alcohol-extract	3·98
Water-extract	3·72
Fat	0·34
Salts	8·58

The fluid was slightly bloody, and on standing deposited a yellow sediment.

2. In a case of metroperitonitis and bronchopneumonia there was found in the abdomen a reddish-yellow fluid which developed a little sulphuretted hydrogen, had a well-marked acid reaction from the presence of free lactic acid, and coagulated perfectly on heating. The fluid separated from the coagulum by filtration had an acid reaction, was of a yellow colour, and contained much extractive matter in solution. On warming it with carbonate of zinc, filtering, and evaporating, crystals of lactate of zinc were readily obtained.

In 1000 parts there were contained:

Water	909·83	
Solid residue	90·17	
Cells	12·95	Protein 48·95
Albumen	36·00	
A substance resembling pyin	8·96	Transformed tissues 33·41
Fat and alcohol-extract	14·105	
Free lactic acid	1·05	
Ammonia salts and water-extract	9·30	
Fixed salts	8·88	

The exudation in the pleural sac was of a blood-red colour, although no blood-corpuscles could be detected by the microscope. It was strongly acid.

In 1000 parts there were contained:

Water	936·718	
Solid residue	63·282	
Albumen	31·746	
Fat and extractive matter	25·503	Transformed tissues 27·113
Free lactic acid	1·610	
Fixed salts	7·110	

3. In another case of metroperitonitis the fluid in the abdominal cavity was of a yellowish-gray colour, neutral, and coagulated freely on heating.

In 1000 parts there were contained:

Water	909·79	
Solid constituents	90·21	
Albumen	48·17	
Alcohol-extract	14·16	Transformed tissues 32·83
Fat	1·97	
Water-extract	6·80	
A substance thrown down by acetic acid	9·90	
Fixed salts	9·00	

4. In a similar case, the abdominal exudation separated in a short time into a purulent deposit, and a reddish-yellow supernatant fluid. The microscope revealed the presence of cells, organisms resembling minute algæ, granules, and nuclei. The exudation had a faintly acid reaction and developed a considerable quantity of sulphuretted hydrogen.

In 1000 parts there were contained:

Water	902·70	
Solid constituents	97·30	
Pus- and exudation- corpuscles	13·81	Protein-compounds 50·63
Albumen precipitable by water	12·98	
Albumen coagulated by boiling	23·84	
A substance thrown down by acetic acid and not soluble in an excess	12·41	Metamorphosed tissue 38·93
Alcohol-extract	14·96	
Water-extract	5·36	
Fat	6·20	
Fixed salts	8·83	

5. A similar fluid in a case of 'metritis septica' was strongly acid, and contained in 1000 parts:

Water	905·74	
Solid constituents	94·26	
Pus- and exudation-cells	14·67	Protein-compounds 47·14
Coagulable albumen	32·46	
Fat	6·91	Metamorphosed tissue 38·88
Lactic acid	1·50	
A substance precipitable by acetic acid	10·42	
Alcohol-extract	12·60	
Water-extract	7·45	
Fixed salts	9·38	

6. The abdominal exudation in a case of metroperitonitis and endometritis differed from the preceding fluids in not depositing a purulent sediment, but after standing for a considerable time remained turbid and of a yellowish-red colour. Under

the microscope there were seen free granules and nuclei, together with exudation globules filled with granular contents. It was strongly alkaline.

In 1000 parts there were contained:

Water	966·10
Solid constituents	33·90
Albuminate of soda	18·72
Fat	1·35
Extractive matters	6·12
Salts	8·73

7. In a case of 'perimetritis, metritis, and endometritis,' the microscopic characters of the fluid were similar to those in the preceding case. The exudation was neutral. When boiled it coagulated and deposited flocculi; the filtered liquid was rendered turbid by acetic acid, and the turbidity did not disappear on the addition of an excess of the test. The fluid was, however, rendered clear by the addition of hydrochloric acid. These reactions show that the precipitated substance was not casein, but pyin.

In 1000 parts there were contained:

Water	941·27	
Solid constituents	58·73	
Albumen	25·21	Unchanged protein
Pyin	4·37	Metamorphosed tissue 27·17
Fat	2·32	
Alcohol-extract	12·27	
Water-extract	8·11	
Fixed salts	7·93	

8. We shall conclude this series of cases with a notice of the analysis of the fluid found in the peritoneum of a boy aged 8 years, who died from perienteritis. The exudation deposited a sediment similar to those described as forming in the preceding cases of puerperal fever; it was neutral and coagulated on boiling.

It contained in 1000 parts:

Water	980·00
Solid constituents	20·00
Albumen	6·49
Pyin	2·45
Extractive matters	4·74
Salts	6·32

APPENDIX.

APPENDIX I.

Note 1. *Ultimate composition of protein.* (Mulder.)

	Vegetable albumen.	Fibrin.	Albumen.	Atoms.	Calculated.
Carbon . .	54·99	55·44	55·30	40	55·29
Hydrogen . .	6·87	6·95	6·94	31	7·00
Nitrogen . .	15·66	16·05	16·02	5	16·01
Oxygen . .	22·48	21·56	21·74	12	21·70

Liebig's formula C_{48} H_{36} N_6 O_{14} is founded on a series of analyses by Scherer, and gives C 55·742, H 6·827, N 16·143, O 21·228.

Note 2. *Ultimate composition of tritoxide of protein.* (Mulder.)

	1.	2.	3.	4.	Atoms.	Calculated.
Carbon . .	51·47	51·69	51·38	51·48	40	51·45
Hydrogen . .	6·60	6·64	6·78	6·56	32	6·72
Nitrogen . .	15·37	15·09	15·01	—	5	14·90
Oxygen . .	26·56	26·58	26·82	—	16	26·93

1 was prepared from chlorite of protein, of which the chlorine had been removed by ammonia; 2, by boiling fibrin in water; 3, by boiling albumen in water; and 4, from an inflammatory crust.

Note 3. *Ultimate composition of binoxide of protein.*

	1.	2.	3.	Atoms.	Calculated.
Carbon . .	53·69	53·64	53·44	40	53·36
Hydrogen . .	6·90	6·88	7·04	31	6·75
Nitrogen . .	15·63	15·85	14·51	5	15·45
Oxygen . .	23·71	23·64	25·01	14	24·44

1 was obtained by boiling fibrin in water; it then remains behind insoluble; 2, is the albuminose of Bouchardat (Comptes Rendus, 20 Juin 1842). Von Baumhauer, in Scheikund. Onderzoek. Deel 1, p. 568; 3 was obtained from hair (see Vol. I, p. 11.) These analyses were made in Mulder's laboratory.

NOTE 4. *Ultimate composition of erythroprotid.* (Mulder.)

		Atoms.	Calculated.
Carbon . . .	56·63	13	56·12
Hydrogen . . .	5·93	8	5·64
Nitrogen . . .	10·23	1	10·00
Oxygen . . .	27·21	5	28·24

NOTE 5. *Ultimate composition of leucin.* (Mulder.)

	1.	2.	Atoms.	Calculated.
Carbon . .	55·64	55·53	12	55·79
Hydrogen . .	9·30	9·32	12	9·11
Nitrogen . .	10·51	10·51	1	10·77
Oxygen . .	24·55	24·74	4	24·33

NOTE 6. *Ultimate composition of protid.* (Mulder.)

		Atoms.	Calculated.
Carbon . . .	59·20	13	59·04
Hydrogen . . .	6·62	9	6·67
Nitrogen . . .	10·56	1	10·52
Oxygen . . .	23·62	4	23·77

NOTE 7. *Ultimate composition of albumen of the blood.* (Mulder.)

		Atoms.	Calculated.
Carbon . . .	54·84	400	54·70
Hydrogen . . .	7·09	310	6·92
Nitrogen . . .	15·83	50	15·84
Oxygen . . .	21·23	120	21·47
Phosphorus . .	0·33	1	0·35
Sulphur . . .	0·68	2	0·72

In a few instances (see Vol. I, pp. 1—3, 181, and Vol. II, pp. 8, 424, &c.) I find that I have doubled the equivalent of phosphorus. Adopting this notation in p. 16, the formula, instead of being $10\,\overline{Pr} + S_2P$, would become $10\,\overline{Pr} + S_2\overline{P}_2$.

Albumen of eggs differs from the above in containing only half the amount of sulphur. Mulder's analysis gave:

		Atoms.	Calculated.
Carbon . . .	54·48	400	54·90
Hydrogen . . .	7·01	310	6·95
Nitrogen . . .	15·70	50	15·89
Oxygen . . .	22·00	120	21·55
Phosphorus . .	0·43	1	0·35
Sulphur . . .	0·38	1	0·36

NOTE 8. *Ultimate composition of fibrin from ox-blood.* (Mulder.)

		Atoms.	Calculated.
Carbon	54·56	400	54·90
Hydrogen	6·90	310	6·95
Nitrogen	15·72	50	15·89
Oxygen	22·13	120	21·55
Phosphorus	0·33	1	0·35
Sulphur	0·36	1	0·36

Hence, in its composition, it is identical with the albumen of eggs.

NOTE 9. *Ultimate composition of casein from cows' milk.* (Mulder.)

		Atoms.	Calculated.
Carbon	54·96	400	55·10
Hydrogen	7·15	310	6·97
Nitrogen	15·80	50	15·95
Oxygen	21·73	120	21·62
Sulphur	0·36	1	0·36

NOTE 10. *Ultimate composition of crystallin from the eye.* (Mulder.)

Carbon	55·39	
Hydrogen	6·94	
Nitrogen	16·51	hence it closely resembles casein.
Oxygen	20·91	
Sulphur	0·25	

NOTE 11. *Ultimate composition of globulin.*

The analysis referred to in the text was published by Mulder in the 'Bulletin' for 1839. In his recent work on the 'Chemistry of Animal and Vegetable Physiology,' he states that, although a protein-compound, its real composition is not yet known.

NOTE 12. *Ultimate composition of pepsin.* (Vogel.)

Carbon	57·718
Hydrogen	5·666
Nitrogen	21·088
Oxygen	16·064

Note 13. *Ultimate composition of chondrin.* (Scherer.)

	Cartilage of the ribs of a calf.		Cornea.	Atoms.	Calculated.
Carbon .	49·496	50·895	49·522	48	50·745
Hydrogen .	7·133	6·962	7·097	40	6·904
Nitrogen .	14·908	14·908	14·399	6	14·692
Oxygen .	28·463	27·235	28·982	20	27·659

Mulder obtained from costal cartilage:

		Atoms.	Calculated.
Carbon . .	49·96	320	49·93
Hydrogen . .	6·63	260	6·61
Nitrogen . .	14·44	40	14·47
Oxygen . .	28·59	140	28·58
Sulphur . .	0·38	1	0·41

Note 14. *Ultimate composition of glutin.* (Mulder.)

	Glutin from hartshorn.		Glutin from isinglass.	Atoms.	Calculated.
	1.	2.			
Carbon .	50·05	50·05	50·76	13	50·37
Hydrogen .	6·48	6·64	6·64	10	6·33
Nitrogen .	18·35	18·39	18·31	2	17·95
Oxygen .	25·12	24·92	24·29	5	25·35

Note 15. *Ultimate composition of glycicoll or gelatin sugar.* (Mulder.)

		Atoms.	Calculated.
Carbon . . .	34·27	8	34·39
Hydrogen . .	6·51	9	6·32
Nitrogen . .	19·84	2	19·92
Oxygen . .	39·38	7	39·37

Note 16. *Ultimate composition of hæmatin.* (Mulder.)

	1.	2.	3.	Atoms.	Calculated.
Carbon .	66·49	66·20	65·73	44	65·84
Hydrogen	5·30	5·44	5·28	22	5·37
Nitrogen	10·54	10·46	10·57	3	10·40
Oxygen .	11·01	11·15	11·97	6	11·75
Iron .	6·66	6·75	6·45	1	6·64

1 and 2 were prepared from arterial and 3 from venous ox-blood.

NOTE 17. *Ultimate composition of cholic acid.* (Dumas.)

		Atoms.	Calculated.
Carbon . . .	68·5	42	68·8
Hydrogen . . .	9·7	36	9·6
Oxygen . . .	21·8	10	21·6

NOTE 18. *Ultimate composition of urea.*

	Prout.	Liebig and Wöhler.	Atoms.	Calculated.
Carbon .	19·99	20·02	2	20·198
Hydrogen .	6·65	6·71	4	6·595
Nitrogen .	46·65	46·73	2	46·782
Oxygen .	26·63	26·54	2	26·425

NOTE 19. *Ultimate composition of uric acid.*

	Prout.	Mitscherlich.	Liebig and Wöhler.	Atoms.	Calculated.
Carbon .	39·875	35·82	36·082	5	36·00
Hydrogen	2·225	2·38	2·441	2	2·36
Nitrogen	31·125	34·60	33·361	2	33·37
Oxygen .	26·775	27·20	28·126	3	28·27

NOTE 20. *Ultimate composition of hippuric acid.*

The hydrated acid contains:

	Mitscherlich.	Liebig.	Dumas.	Atoms.	Calculated.
Carbon .	60·63	60·742	60·5	18	60·9
Hydrogen .	4·98	4·959	4·9	9	4·9
Nitrogen .	7·90	7·816	7·7	1	7·8
Oxygen .	26·49	26·483	26·9	6	26·4

NOTE 21. *Ultimate composition of uric oxide.* (Liebig and Wöhler.)

		Atoms.	Calculated.
Carbon . .	39·28	5	39·86
Hydrogen . .	2·95	2	2·60
Nitrogen . .	36·35	2	36·72
Oxygen . .	21·42	2	20·82

NOTE 22. *Ultimate composition of cystin.*

	Prout.	Thaulow.	Atoms.	Calculated.
Carbon . .	29·875	30·01	6	30·31
Hydrogen . .	5·125	5·10	6	4·94
Nitrogen . .	11·850	11·60	1	11·70
Oxygen } .	53·150	{ 28·38	4	26·47
Sulphur }		25·51	2	26·48

NOTE 23. *Ultimate composition of glycerin.* (Pelouze.)

	Hydrated.	Atoms.	Anhydrous.	Atoms.
Carbon . .	39·59	6	43·84	6
Hydrogen . .	8·61	8	8·35	7
Oxygen . .	51·80	6	47·84	5

NOTE 24. *Ultimate composition of stearic acid.* (Redtenbacher.)

		Atoms.	Calculated.
Carbon . .	76·71	68	76·76
Hydrogen . .	12·86	68	12·90
Oxygen . .	10·46	7	10·34

Ultimate composition of margaric acid. (Redtenbacher.)

		Atoms.	Calculated.
Carbon . .	75·64	34	75·64
Hydrogen . .	12·86	35	12·71
Oxygen* . .	11·50	4	11·65

The former contains two, and the latter one atom of water.

NOTE 25. *Ultimate composition of lactic acid.*

Lactic acid has been analysed by several chemists, who have all arrived at nearly the same results.

	Hydrated.	Atoms.	Anhydrous.	Atoms.
Carbon . .	40·46	6	44·92	6
Hydrogen . .	6·61	6	6·55	5
Oxygen . .	52·93	6	48·53	5

NOTE.—In vol. i, p. 222, it was inadvertently stated that hippuric acid is non-nitrogenous. The object of the author is to show that, compared with uric acid, it contains very little nitrogen.

APPENDIX II.

ADDITIONS TO VOLUME I.

PAGE 300. *Blood in thoracic inflammation.* Zimmermann[1] has communicated several observations respecting the blood in inflammatory affections of the respiratory organs. The following are the results of his analyses, conducted according to the method of Andral and Gavarret:

	Water.	Fibrin.	Blood-corpuscles.	Res. of serum.
1.	790·0	3·0	127·0	80·0
2.	784·0	4·0	126·0	86·0
	796·0	6·0	119·0	79·0
3.	810·0	7·0	106·0	77·0
	805·0	5·0	103·5	85·5
4.	806·0	9·6	109·9	74·5
5.	774·0	4·0	142·0	80·0
	781·0	4·0	137·0	78·0
	786·0	4·0	131·5	78·5
6.	796·0	3·0	128·0	73·0
7.	794·0	3·0	123·5	79·5
8.	792·0	3·0	120·0	89·0
9.	800·0	4·0	119·5	76·5
10.	800·0	4·0	108·0	88·0
11.	798.0	7·0	116·0	79·0
	815·0	8·0	100·5	76·5
12.	806·0	3·5	100·5	90·0

If we compare the mean of these analyses with the average deduced by Andral and Gavarret from 58 analyses of the blood in similar cases, we have:

Zimmermann	796·2	4·75	118·10	80·85
Andral	799·0	7·30	114·10	81·00

[1] Zur Analysis und Synthesis der pseudoplastichen Prozesse, pp. 1841-99.

The leading difference in these averages occurs in the fibrin. Zimmermann suggests that probably Andral and Gavarret used only buffed blood.

Page 302. *Blood in intermittent fever* In four cases in which the blood of persons residing in malarious districts, who were suffering from intermittent fever, was analysed by Cozzi, the fibrin occurred in its normal quantity, but the fat and albumen were diminished. In three of these cases there was a great excess of cholesterin, and scarcely any phosphates; in the remaining case (No. 3) these salts were abundant, while no cholesterin was found.

The following are the results of Cozzi's analyses:

	1.	2.	3.	4.
Water and salts .	737·67	705·49	732·45	809·17
Fibrin . .	2·20	2·06	2·29	1·96
Fat . .	·15	·21	·13	·16
Albumen .	48·71	56·61	47·59	53·10
Blood-corpuscles .	211·27	235·63	217·54	135·61

The blood in (1) was taken from a soldier with severe intermittent fever, accompanied with considerable enlargement of the spleen and liver.

The blood in (2) was taken from a man with a quartan fever, whose spleen and liver were much enlarged, and the latter the seat of excruciating pain.

The blood in (3) was taken from an artilleryman, who for five years had been stationed in a malarious district. It was a case of intermittent fever, with slight enlargement of the liver, but extraordinary hypertrophy of the spleen.

The blood in (4) was taken from a man with angina tonsillaris, who had suffered from fever for a long time: spleen enlarged and very painful.

In addition to the excess of cholesterin in the majority of these cases, bile-pigment was observed in the blood. The connexion between the occurrence of these constituents and the deranged state of the portal system is sufficiently obvious.

Page 304. *Blood in certain diseases of the eye.* Zimmermann has published the following analyses of the blood in

a peculiar form of endemic ophthalmia recently prevalent at Berlin.

1. In a case of ophthalmia of two days' standing, accompanied with much chemosis, the specific gravity of the blood was 1051. The specific gravity of the serum was 1027, and of the clot 1086.

In 1000 parts there were:

Water	798·0
Solid constituents	202·0
Fibrin	2·0
Blood-corpuscles	117·5
Solid residue of serum	82·5

The serum was of a blueish-red colour and opaque.

2. The blood drawn from a patient on the third day of the ophthalmia had a specific gravity of 1052. The specific gravity of the serum was 1028 and of the clot 1090.

In 1000 parts there were:

Water	795·0
Solid residue	205·0
Fibrin	2·0
Blood-corpuscles	115·1
Solid residue of serum	87·9

3. A patient on the second day of the disease yielded blood of specific gravity 1055. The specific gravity of the serum was 1030, and of the clot 1092.

In 1000 parts there were contained:

Water	790
Solid residue	210
Fibrin	2
Blood-corpuscles	115
Solid residue of serum	93

4. In a similar case the blood had a specific gravity of 1054. The specific gravity of the serum was 1035, and of the clot 1088.

In 1000 parts there were contained:—

Water	794
Solid constituents	206
Fibrin	3
Blood-corpuscles	105
Solid residue of serum	9

5. A soldier with conjunctivitis and sclerotitis of the right eye. The specific gravity of the blood was 1052. The specific gravity of the serum was 1030, and of the clot 1084.

In 1000 parts there were contained:

Water	795·0
Solid constituents	205·0
Fibrin	2·5
Blood-corpuscles	104·0
Solid residue of serum	98·5

6. In a case of conjunctivitis of both eyes without fever, the specific gravity of the blood was 1055. The specific gravity of the serum was 1036, and of the clot 1088.

In 1000 parts there were contained:

Water	786·0
Solid constituents	214·0
Fibrin	2·0
Blood-corpuscles	113·5
Solid residue of serum	98·5

7. In a case of ophthalmia of the left eye, the specific gravity of the blood was 1055. The specific gravity of the serum was 1031, and of the clot 1090.

In 1000 parts of blood there were contained:

Water	790·0
Solid constituents	210·0
Fibrin	2·0
Blood-corpuscles	114·7
Solid residue of serum	93·3

Three days having elapsed, venesection was again ordered. The specific gravity of the blood was then 1050·8. The specific gravity of the serum was 1027·7, and of the clot 1078.

In 1000 parts there were contained:

Water	802·0
Solid constituents	198·0
Fibrin	2·0
Blood-corpuscles	116·2
Solid residue of serum	89·8

8. The blood of a soldier on the third day of the disease had a specific gravity of 1052. The specific gravity of the serum was 1031, and of the clot 1080.

In 1000 parts there were contained:

Water	796·0
Solid constituents	204·0
Fibrin	2·5
Blood-corpuscles	106·7
Solid residue of serum	93·8

Four days afterwards the specific gravity was 1050·5. The specific gravity of the serum was 1028, and of the clot 1078.

In 1000 parts there were contained:

Water	800
Solid constituents	200
Fibrin	2
Blood-corpuscles	108
Solid residue of serum	90

After an interval of ten days he was again bled. The specific gravity was 1050. The specific gravity of the serum was 1027, and of the clot 1078.

In 1000 parts there were contained:

Water	804·0
Solid constituents	196·0
Fibrin	3·5
Blood-corpuscles	97·0
Solid residue of serum	95·5

A glance at the leading characters of the blood in these eight cases, will show, that in these patients it was in a state of hypinosis.

PAGE 309. *Blood in scrofula.* The blood in this form of disease has been analysed by Mr. Nicholson.[1]

The analyses were conducted on Andral and Gavarret's method:—

[1] Northern Journal of Medicine, Nov. 1845.

	Water.	Fibrin.	Blood-corpuscles.	Resid. of serum.
1.	816·5	3·0	101·0	79·5
2.	820·2	2·8	98·0	79·0
3.	820·5	2·4	98·0	79·1
4.	821·0	3·0	97·0	79·0
5.	823·0	2·5	96·5	78·0
6.	839·0	2·3	80·0	78·7
7.	843·0	2·0	79·0	79·0
8.	839·0	2·0	79·0	80·0
9.	855·3	1·2	63·5	80·0
10.	855·2	1·8	64·0	79·0
11.	854·3	1·7	65·5	78·5
12.	855·0	2·0	64·0	79·0

The blood-corpuscles were few, light coloured, and irregular, and there was sometimes an appearance as if their circumference was notched and divided.

PAGE 325. *Blood in Bright's disease.* In a case of albuminuria, in which the dropsy was only of a fortnight's standing, the blood was analysed by Dr. Ayres.[1] There was a firm buffy coat on the blood, a quarter of an inch in thickness.

The coagulum itself was very firm, and so bulky as almost to fill the glass.

There were contained in 1000 parts:

Water	765·022
Solid constituents . . .	234·978
Fibrin and tritoxite of protein .	11·450
Fat	a trace
Albumen . . .	65·875
Hæmatoglobulin . . .	138·185
Albuminate of soda and salts .	13·940
Osmazome . . .	1·510

No urea could be detected in this blood, the leading characters of which were a great increase of fibrin and a diminution of the water and fat.

The following analyses have been recently published by Heller.[2]

[1] Lancet, Aug. 2, 1845.

[2] Archiv für Physiologische und Pathologische Chemie und Mikroskopie, vol. ii, p. 173.

1st Case.—A man of tolerably robust appearance, aged 38 years. The disease was somewhat advanced, and there was considerable œdema. The blood was analysed on two occasions. On the first occasion it was taken by cupping from the region of the kidney. It was very fluid but of the normal colour. The clot was small and presented no peculiarity. The serum was slightly coloured. Under the microscope the blood-corpuscles appeared large and swollen. The blood was tested for urea, and found to contain a considerable quantity.

Five ounces were subsequently removed by venesection. The colour of the blood on this occasion was rather dark, and the coagulation was perfect. The clot was of a bright red colour on the surface, but otherwise dark, and there was no buffy coat. The serum was very pale and opalescent, and its specific gravity was only 1022. It contained no bile-pigment, and its reaction was strongly alkaline.

In 1000 parts were contained:

Water	805·39	
Solid constituents	194·61	
Fibrin	3·52	
Albumen	51·45	Solid residue of serum 68·15
Fixed salts	6·70	
Extractive matter	8·15	
Urea	1·85	
Hæmatoglobulin	122·94	

2d Case.—A woman, aged about 30 years, with the disease in an early stage. There was slight œdema of the feet and face, accompanied with pain in the region of the kidneys. Four ounces of blood taken from the arm presented no physical peculiarities. The specific gravity of the serum was only 1018, or 10° lighter than normal serum. The clot was to the serum in the ratio of 544·75 : 455·25.

In 1000 parts of blood there were contained:

Water	816·04	
Solid constituents	183·96	
Fibrin	2·66	
Albumen with a little extractive matter	48·03	Solid residue of serum 56·73
Fixed salts	6·96	
Urea	1·74	
Hæmatoglobulin	124·57	

Heller's general conclusions respecting the blood in Bright's disease are that the specific gravity and the amount of solid

constituents are diminished, and that the diminution is dependent alone on the decrease of the albumen, which, for the most part, is found in the urine, but to a less degree also in the dropsical effusions. The appearance of the blood is normal, and in its coagulation it presents no peculiarity. The serum is pale, of low specific gravity (as may be shown by the common urinometer), and contains no bile-pigment.

The fibrin and blood-corpuscles occur in the ordinary quantity. The solid residue of the serum is much diminished in consequence of the great decrease of the albumen. Urea is abundant in the blood; in the first analysis it amounted to 1·85 in 1000 parts: reckoning the whole amount of blood in the body at thirty pounds, this would contain about an ounce of urea. The presence of urea in the blood must not, however, be regarded as peculiar to Bright's disease, since it has been found in a large quantity in cholera, ischuria, and other diseases associated with suppression of urine.

The fixed salts present no remarkable deviation from the normal standard, but are usually slightly below the healthy average.

PAGE 338. *Menstrual fluid.* Since the publication of the first volume, an analysis of this secretion has been made by Dr. Letheby.[1] The menses were retained by an imperforate hymen, which, when cut into, permitted the escape of about forty ounces of a thick and almost black fluid, having the appearance of treacle. When examined under the microscope, with a power of 300, it was found to be quite free from fibrin, but numerous corpuscles were observed floating in it. The greater number of them were altered blood-corpuscles, but there were also noticed the exudation or inflammatory globules (of Gerber and Glüge), lymph-corpuscles, mucus-corpuscles, epithelium-scales, and minute granules resembling mere dots.

The fluid had an alkaline reaction, and was perfectly miscible with water; when heated a little below 212°, it formed a firm coagulum.

It was analysed in accordance with Simon's directions, and was found to contain:—

[1] Lancet, Aug. 2, 1845.

Water	857·4
Solid Constituents	142·6
Fat	5·3
Albumen	69·4
Globulin	49·1
Hæmatin	2·9
Salts	8·0
Extractive matters	6·7

Another analysis was formed with the view of estimating the quantity of mucus, blood-corpuscles, and soluble albumen, and gave the following results:

Water	857·4
Solid matters insoluble in cold water, and consisting of mucous, lymph, and exudation globules with epithelium	22·6
Solid matters soluble in cold water, and consisting of saponified fats and blood-corpuscles	53·8
Albumen	52·7
Salts	7·0

These must be taken as the constituents of the fluid. It can, however, hardly be regarded as the normal menstrual secretion; from the length of time in which it remained in the vagina it became mixed with an excess of mucus, and, acting as an irritant, produced the inflammatory globules that were observed in it.

ADDITIONS TO VOLUME II.

PAGE 9. *Saliva.* Lassaigne has instituted a series of experiments in reference to the animal diastase of Mialhe. The results of these experiments are as follows:

a. Human saliva, and that of the horse, at the temperature of 103°, exert no solvent power on starch, which remains quite unaltered in its physical and chemical properties.

b. At a higher temperature (158° to 167°) maintained for three hours and a half, horse's saliva acts on starch exactly as water does; that is to say, the granules become tumid and distended, without being changed into either dextrine or glucose.

c. Human saliva obtained from the mouth has no action on starch at the temperature of the body; but converts it rapidly into dextrine at a temperature between 158° and 167°, and subsequently converts the dextrine into glucose.

d. During the digestion of raw amylaceous substances, the saliva, being at the temperature of the animal body, cannot exert the influence attributed to it by Mialhe; it can merely, as most of the older and modern physiologists maintain, contribute to moisten the alimentary bolus, and dissolve such of its principles as are soluble in water.

PAGE 12. *Morbid saliva.* Scherer has analysed the saliva of a girl aged 15 years, suffering from a scorbutic affection of the mouth. There was copious ptyalism, the saliva amounting to about 40 ounces in twenty-four hours. The secretion was very liquid, fetid, and alkaline. The specific gravity was 1004.

In 1000 parts there were contained:

Water	988·8
Solid constituents	11·2
A caseous-like substance precipitable by acetic acid	6·5
Fat taken up by ether	0·6
Extractive matter and ptyalin	1·8
Carbonate of soda	1·2
Chloride of sodium	0·7
Phosphate of lime	0·4

On examining with the microscope the fluid immediately after its discharge, there were found in it a large number of infusoria, and a peculiar confervoid-like vegetation.

PAGE 15. *Fluid of ranula.* Dr. Gorup-Besanez[1] has published an elaborate paper on this subject, in which, after discussing at considerable length the question whether the tumour constituting ranula arises from an obstruction of Wharton's duct, and contains retained and modified saliva, or whether it is a species of ordinary cystic tumour, he arrives at the latter conclusion. In 100 parts of fluid he found:

Water	95·029
Solid constituents	4·971
Alcohol-extract, traces of fat, and chloride of sodium	1·062
Water-extract (gluten?)	0·923
Albuminate of soda	2·986

The microscope detected in the fluid some blood-corpuscles and globules which were at least twice as large as the corpuscles of mucus or saliva, and resembled Gluge's inflammatory globules.

Hence the liquid differed entirely, both chemically and microscopically, from saliva.

PAGE 19. *The bile.* Frerichs[2] has recently analysed bile both in health and disease. He gives the following as the physical characters of healthy human bile.

In colour it is always deep brown, but, when seen in thin layers, it has a brownish yellow tint. It is very fluid, being viscid only in new-born infants. The specific gravity varies from 1032 to 1040. On examining with the microscope bile from the gall-bladder, with which, of course, a certain amount of mucus is mixed, there are observed:—1. Transparent or grayish round vesicles, about 1-700th of a line in diameter. They disappear on the addition of alcohol or ether, and are removed by filtration. 2. Conical yellow bodies, about 1-140th of a line in length, and about 1-300th or 1-400th of a line in breadth, apparently devoid of nuclei; these are epithelium-cells from the gall-bladder. 3. Here and there irregular dark granules,

[1] Heller's Archiv für Phys. und Patholog. Chemie und Mikroskopie, vol. ii, p. 22.

[2] Hannov. Annal. 1 and 2, 1845.

which disappear on the addition of a solution of potash, apparently pigment-cells. 4. Occasionally minute crystals of cholesterin, occurring as colourless rhombic tablets. The chemical characters are shown in the two following analyses. The bile in these cases was obtained from healthy men, killed by severe accidents:

	1.	2.
Water . . .	86·00	85·92
Solid constituents . .	14·00	14·08
Bilate of soda . .	10·22	9·14
Cholesterin . .	0·16	0·26
Margarin and olein . .	0·32	0·92
Mucus . . .	2·66	2·98
Chloride of sodium . .	0·25	0·20
Tribasic phosphate of soda .	0·20	0·25
Basic phosphate of lime " magnesia	0·18	0·28
Sulphate of lime . .	0·02	0·04
Peroxide of iron . .	traces	traces

PAGE 23. *Morbid bile.* Frerichs has published the two following analyses of morbid bile:

	Bile in pneumonia.	Bile in chronic meningitis.
Water . .	94·60	95·98
Solid constituents .	5·40	4·02
Bilate of soda .	4·16	2·63
Fat . .	0·42	0·20
Mucus and salts .	1·00	1·21

PAGE 27. For further information on the uses of the bile we must refer the reader to the recent work of Platner, 'Ueber die Natur und den Nutzen der Galle,' Heidelberg, 1845. A summary of his views on this subject is given in Müller's Archiv, No. 4, 1845.

PAGE 29. *Gastric juice.* Dr. R. D. Thompson has published an account of a series of experiments made with the view to determine the acid or acids occurring in the gastric juice. In order to prevent complication of the phenomena, the animals were fed on vegetable food alone. His experiments tend to show that no free hydrochloric acid is present in the stomach of animals living on vegetable food, but that the free acid is the lactic. A little acetic acid was also generally present. A full account of his experiments may be seen in the 'London Medical Gazette,' Oct. 1845, or in the 'Half-yearly Abstract of the Medical Sciences,' vol. ii, pp. 347-51.

PAGE 42. *Vicarious secretion of milk.* A singular case of this nature is recorded in Vol. I, p. 65. During the last summer the following case has been published. Professor Cannobio[1] received five or six ounces of a liquid that flowed from an abscess in the thigh of a woman who was suckling. In appearance it resembled whey, but was somewhat whiter. It was homogeneous, and, after remaining in a bottle for thirty-five hours, threw down no sediment. Its specific gravity was 1010. It remained alkaline for seven days, and then became slightly acid. On the addition of a few drops of acetic acid, it became slightly turbid, but there was no sensible deposit until the expiration of the second day.

On analysing the fluid according to Haidlen's directions, it was found to contain in 1000 parts:

Water	982·64
Solid constituents	17·36
Butter with traces of cholesterin	2·77
Sugar of milk, soluble salts, and alcohol-extract	7·29
Casein and insoluble salts	6·25
Fragments of linseed from poultices, &c.	1·06

PAGES 42 and 49. *Milk.* The references to the plate are omitted in the text. (See plate 2, figs. 13* A and B.)

PAGE 61. The reader would do well to consult Dr. Davy's paper on 'the colostrum of the cow,' in the Medico-Chirurg. Transactions, 1845.

PAGE 67. *Bitches' milk.* Dumas[2] has recently published some analyses of the milk of bitches, the object of his paper being to show that, after they have been restricted for some time to a purely animal diet, all traces of sugar disappear from the milk. A bitch fed on bread, meat, bone, and fat, yielded milk containing:

Water	69·80
Solid constituents	30·20
Butter	12·40
Extractive matter	2·50
Casein	13·60
Soluble salts	0·71
Insoluble salts	0·77

The sugar in this instance crystallized on the surface of the extractive matter.

[1] Journal de Pharmacie, Août, 1845.

[2] Annales des Sciences Nat., Sept. 1845.

After feeding, for the space of a fortnight, on horseflesh alone, the milk yielded:

Water	77·14
Solid constituents	22·86
Butter	7·32
Casein	11·15
Extractive matter	3·39
Soluble salts	0·45
Insoluble salts	0·57

Not a trace of sugar could be detected in the latter specimen. His other analyses are merely confirmatory of the same fact.

Dumas believes that the milk-globules are surrounded by a caseous investment; he found that if milk be shaken with pure ether, the two liquids which are at first mixed, separate on standing, and the milk preserves its ordinary appearance, whilst the ether dissolves scarcely anything. If, however, acetic acid is added to the milk, and the mixture is boiled, the whole of the butter may be removed by subsequent agitation with ether, and the milk ceases to be opalescent.

PAGE 119. *Colouring matters of urine.* Heller has recently published some observations on certain new colouring matters in the urine. He believes that there exists a yellow pigment (uroxanthin) which occurs in solution in very small proportion in healthy urine, but is much increased in certain forms of disease. It possesses the property of being converted by oxidation (either spontaneously or artificially) into two other pigments, one of which is of a ruby-red tint, (urrhodin,) while the other is of the colour of ultramarine, (uroglaucin.)

These are both insoluble in the urine, and being deposited, form a purple or violet-coloured sediment.

That uroxanthin and its products are derived from urea seems probable, from the circumstance that uroglaucin and urrhodin occur in diseases different in most of their characters, but similar in one—the presence of an excess of urea in the blood: thus they are found in Bright's disease, in cholera, and in suppression of urine. Further, when these products occur in considerable quantity, (especially when the blue sediment is spontaneously formed,) there is always much carbonate of ammonia, and very little urea (perhaps mere traces) in the urine, as is often the case in Bright's disease. Finally, Heller has

observed the blue tint developed by nitrate of urea artificially prepared and kept moist, and has likewise produced it by adding nitric acid to an old solution of urea partially converted into carbonate of ammonia.

The existence of a large quantity of uroxanthin in urine is indicated:

1. By the clear light-yellow colour of the urine when that secretion is acid, as in cholera, and sometimes in Bright's disease.

2. By the presence of the products of its oxidation, uroglaucin and urrhodin, which either of themselves form a violet-coloured sediment, or communicate that tint to a sediment already formed.

On allowing urine abounding in uroxanthin to stand for some time, it is observed that after the formation of the sediment has ceased, the fluid from the surface downwards assumes a violet tint, and this change of colour takes place with a rapidity proportional to the amount of carbonate of ammonia produced by the decomposition of urea.

Hence, on keeping such urine in a high cylindrical glass, three distinct strata are observed; lowermost, a violet sediment; in the middle, yellow and nearly clear urine; and superiorly, a violet or purple turbid layer.

On shaking the glass, the whole urine assumes a bluish-green tint, because the urrhodin, formed principally at the surface, becomes converted, by agitation with a full supply of atmospheric air, into uroglaucin which, mixing with the central yellow layer of urine develops a green tint. The uroglaucin thus formed ultimately settles as a blue powder on the sides and at the bottom of the vessel. Hence there is obviously no fixed proportion between the quantities of uroglaucin and urrhodin.

3. If much uroxanthin is present, the crystals of uric acid (separated either spontaneously or by the addition of an acid) have a beautiful blue or amethyst tint.

4. Lastly, if much uroxanthin is present, it may be recognized by the addition of concentrated nitric acid, (ten drops to half an ounce of urine,) which at once communicates a brilliant violet colour to the fluid: if a smaller amount is present, the change of colour is developed more slowly.

The nitric acid oxydises the uroxanthin, and converts it into uroglaucin and urrhodin. Sulphuric and hydrochloric acids act similarly, but with less activity. If albumen is present in urine treated in this manner, it is either precipitated blue at once, or assumes that tint gradually, according to the amount of uroxanthin. This is constantly noticed in Bright's disease on treating urine abounding in uroxanthin with an acid, and allowing it to stand for a couple of days; uroglaucin separates in dark blue crystalline groups, visible to the naked eye, partly on the surface and partly at the bottom of the vessel. On taking a drop from the surface and examining it under the microscope, uroglaucin is seen in the form represented in Plate iii, fig. 37.

To separate the two products of oxidation of uroxanthin, we collect on a filter the sediment thrown down by nitric acid, and agitate it with cold spirit of ·830, which takes up the urrhodin, (as also does ether;) the residue is boiled for some time with spirit of the same strength, until the fluid becomes somewhat concentrated; we thus get a bright blue solution of uroglaucin.

To exhibit these substances in normal urine, the fluid must be so far evaporated as just to remain liquid. On adding concentrated nitric acid to the cold residue, a crystalline magma of nitrate of urea is at once formed; on adding to this a few more drops of nitric acid (and sometimes even this is unnecessary) it assumes a violet tint. If the crystalline mass is allowed to stand for some time, and is then dissolved in the smallest possible quantity of distilled water, after being left at rest for some time, it deposits a sediment in which urrhodin and uroglaucin may be detected either by the microscope or by extraction with cold and then with boiling spirit.

The action of nitrate of silver on uroxanthin is very singular. On precipitating the chlorine by an excess of nitrate of silver, from urine acidulated with nitric acid, and then carefully neutralizing the filtered liquid by ammonia, there is not only a pale yellow precipitate of phosphate of silver, but the fluid assumes a brown tint, and in a short time there is likewise a brown sediment.

Heller has not yet succeeded in isolating uroxanthin.

Uroglaucin associated with urrhodin, occurs in urinary sediments in Bright's disease, and in cases in which urine,

abundant in uroxanthin, has become alkaline in the bladder. Heller has noticed it in these sediments forming groups of delicate prisms. (See Plate iii, figs. 37 and 38 *a*.) It likewise assumes this form when urine, abounding in uroxanthin, is treated with nitric, sulphuric, or hydrochloric acid. In this case it is principally found on the surface of the fluid.

When allowed to crystallize from its cold spirituous solution, it forms groups which appear nearly black, but are blue and transparent at the edges. (See Plate iii, fig. 38 *a*, *b*.)

Urrhodin appears to be a less oxydised product of uroxanthin than uroglaucin, and usually occurs in much larger quantity. It is most commonly observed in cases in which the urine is alkaline before emission, in consequence of containing much vesical mucus, and its development in such cases is hastened by the addition of nitric acid. The method of isolating it has been already described. Heller has never succeeded in obtaining it from its spirituous solution in a crystalline form. It occurs in granules, which, under the microscope, appear of a beautiful rose-colour. It is resinous in its nature, and burns with a clear flame.

Heller concludes his paper (of which the above is but a brief abstract) with a notice of some experiments on uroerythrin, the ordinary pigment of inflammatory urine.

On treating uric-acid crystals obtained from healthy urine with cold alcohol, the pigment formed a carmine solution, and the uric acid remained comparatively devoid of colour, being of a yellowish-brown tint from the brown pigment of the urine. The spirituous carmine solution on exposure to the air gradually became purple, and had all the properties of uroglaucin, previous to which it appeared to be identical with urrhodin.

On treating the red sediment common in inflammatory affections and tinged with uroerythrin, with hot and cold alcohol and ether, the red pigment remained unaffected, unless a little acid was added. The difference of solubility in the above menstrua is therefore sufficient to separate uroerythrin from urrhodin.

Heller's theory of the production of uroglaucin and urrhodin affords a satisfactory explanation of the occurrence of the blue sediments noticed in pp. 274, 327, and 329.

PAGE 137. *Quantitative determination of urea.* Two papers

on this subject have appeared almost simultaneously during the last three months—one by Ragsky, the other by Heintz.

With regard to the quantitative determination of urea, Ragsky[1] observes there is this great objection to its separation either as a nitrate or oxalate, that both those salts are perceptibly soluble, which prevents on the one hand their complete precipitation, and on the other hand their perfect washing, on which latter account they retain a certain amount of extractive matter. No other compound of urea being known, adapted for its quantitative determination, Ragsky endeavoured to apply the products of its decomposition to this purpose. After several experiments made to this effect, with chlorine and with nitrous acid, he found that concentrated sulphuric acid answers the purpose best. For this purpose, a mixture of one part of urea, with from three to four parts of concentrated sulphuric acid is introduced into a flask, and exposed to the heat of a sand-bath, which must not exceed 572° to avoid loss of ammonia. The decomposition of urea commences at 383° and the evolution of carbonic-acid gas is very lively at 392°. In this process one equivalent of urea assumes the elements of two equivalents of water, and transposing with the latter is converted into two equivalents of carbonic acid which escape as gas, and two equivalents of ammonia which remain in combination with the sulphuric acid.

$$C_2N_2H_4O_2 + 2\,HO + 2\,(SO_3, HO) = 2\,(NH_4O, SO_3) + 2\,CO_2.$$

He determined, in this manner, accurately-weighed portions of pure urea dried at 212 degrees, and determined the ammonia subsequently in the form of ammonio-chloride of platinum. The following numbers will show how approximately urea may be determined in this way.

1. 0·2612 grammes of urea yielded 1·9323 grammes of ammonio-chloride of platinum corresponding to 0·2598 grammes of urea.[2]

2. 0·3139 grammes of urea yielded 2·3175 grammes of ammonio-chloride of platinum, corresponding to 0·3116 grammes of urea.

[1] Liebig and Wöhler's Annalen, Oct. 1845.

[2] The English reader will see the accuracy of the result more clearly by reducing the grammes to grains. From 4·022 grains used in the experiment, 4·001 were recovered.

3. 0·2716 grammes of urea yielded 2·0400 grammes of ammonio-chloride of platinum, corresponding to 0·2743 grammes of urea.

To ascertain how far the presence of extraneous matters might interfere with the accuracy of the results, sugar was mixed with the urea, but the results were unaffected. The next point was to ascertain whether the extractive matter would yield ammonia under these conditions. For this purpose Ragsky precipitated 120 grammes (nearly 4 ounces) of fresh and healthy urina sanguinis, with acetate of lead, after having previously separated the uric acid by means of some hydrochloric acid. The precipitate was mixed with water, decomposed by sulphuretted hydrogen, and the yellow fluid thus produced evaporated to a syrup, and charred with sulphuric acid. The charred mass was subsequently extracted with water, the solution evaporated, and finally treated with alcohol and bichloride of platinum. This process gave no indication of the presence of ammonia. Having thus ascertained that the extractive matters, which are normally present in urine, exercise no adverse influence on the quantitative determination of urea by means of sulphuric acid and bichloride of platinum, he next proceeded to determine by this method the amount of urea present in divers samples of urine, in order to compare the results with those obtained by the ordinary methods. He found, after several experiments, that 7 grammes (a little more than five drachms) of urine required about 3·5 grammes (or half the weight) of concentrated sulphuric acid. If less of the acid be taken the charred mass will readily dry up, and some loss of ammonia will be incurred in consequence. The mixture of urine and sulphuric acid is kept in a moderate state of ebullition, there is a great evaporation of water, and the fluid turns black. The temperature rises higher and higher, until at about 392°. there ensues evolution of carbonic acid gas in small bubbles. The cessation of the disengagement of gas indicates that the urea present in the analysed urine is completely decomposed. The black residue is then thoroughly extracted with water and the solution filtered. The clear and urine-yellow filtrate is finally evaporated in the water-bath, and the sulphate of ammonia treated with alcohol and bichloride of platinum.

Since urine contains salts of potash and ammonia, which

will of course likewise precipitate upon the addition of bichloride of platinum, it is necessary to determine the exact proportion in which these salts are present in the urine under examination. For this purpose a separate weighed portion of urine is precipitated with bichloride of platinum, and the amount of precipitate substracted from the former.

Two samples of urine of 7 grammes each, treated according to this method, yielded 0·202 grammes of urea, or 2·88%, and 0·199 grammes of urea or 2·84%. Fourteen grammes of the same urine was treated according to the ordinary plan; they yielded 0·617 grammes of nitrate of urea, or 2·15% of urea. The extractive matters of the urine yielded no ammonia.

These experiments prove that the method of determining urea in the form of ammonio-bichloride of platinum yields much more accurate results than the plan usually adopted; it may, therefore, in many cases be advantageously employed, with this precaution, that all substances likely to interfere with the accuracy of the process (as uric and hippuric acids, albumen, &c.) be previously removed. It might be advisable in certain cases to separate the urea in the first place by means of oxalic acid, and then to decompose the oxalate with sulphuric acid.

The following table may save trouble in calculation.

1	atom of	ammonio-chloride	of platinum	corresponds to	0·134498	of urea.
2	"	"	"	"	0·268996	"
3	"	"	"	"	0·403494	"
4	"	"	"	"	0·537992	"
5	"	"	"	"	0·672490	"
6	"	"	"	"	0·806988	"
7	"	"	"	"	0·941484	"
8	"	"	"	"	1·075984	"
9	"	"	"	"	1·210482	"

The author concludes his paper by an acknowledgment of the kind assistance of Liebig.

In principle the method adopted by Heintz[1] is so similar to the above, that it is unnecessary to enter into the details. Both writers agree respecting the inaccuracy of the ordinary method.

PAGE 238. *Urine in Bright's disease.* In Heller's memoir already referred to, we find the following analyses of the urine in this disease.

[1] Poggendorff's Annalen, No. 7, 1845.

a. In the case noticed in p. 515, of the man aged 38 years, the urinary secretion was much diminished. The urine was turbid, of a dark yellow colour, very acid, of specific gravity 1017, and deposited a slight, finely flocculent sediment consisting of albuminous fungi, pavement epithelium, the peculiar cylindrical forms observed in Bright's disease, mucus-corpuscles, and a tolerably large number of blood-corpuscles.

On the addition of nitric acid, albumen with a violet tint was precipitated; hence the urine contained a large amount of uroxanthin.[1]

In 1000 parts there were contained:

Water	948·0
Solid constituents	52·0
Urea	6·1
Uric acid	no trace
Fixed salts	3·6
Extractive matters and uroxanthin	23·9
Albumen with some hæmatoglobulin	18·4

The greater part of the salts consisted of sulphate of potash; only slight quantities of chloride of sodium and phosphate of soda were present, and after the removal of the albumen not a trace of earthy phosphates could be detected.

No hippuric acid could be obtained from the urine, and as uric acid was likewise absent, the acidity (which in this case was very marked) could not be dependent on these acids. Heller concludes from various observations that the acid reaction is dependent on the presence of the uroxanthin.

A week afterwards the urine was again analysed. The secretion was still diminished, was very turbid, of a pale reddish colour, and formed a flocculent reddish sediment. The specific gravity was 1010, the reaction acid, and the composition of the fluid nearly the same as when previously examined.

At the expiration of another week, and just before the patient's death, the secretion continued diminished, and the urine rapidly became putrid. The specific gravity was 1011, urea was present in very small quantity, and the sediment contained much pus; in other points the urine remained the same as before.

b. The patient was a man aged 40 years, with considerable œdema of the whole body.

[1] See page 522.

The urinary secretion was much diminished. It was examined on several occasions, principally in reference to the salts.

The urine was of a pale yellow colour, acid, and of specific gravity 1018. There was a slight deposit, consisting of colourless uric-acid crystals, much pavement epithelium, cylinders, albuminous fungi, and a few mucus-corpuscles. The urine contained a large quantity of albumen, very little urea, and only traces of uric acid. The salts amounted to 7·4 in 1000 parts, and contained an excess of sulphates with a diminution of chloride of sodium.

On the following day the organic constituents were similar; the sediment, however, contained in addition some granular cells (the inflammatory globules of Gluge).

The urine was subsequently analysed some days afterwards. It presented the same appearance as before, and the deposit was similar. The reaction was acid, and the specific gravity 1017.

In 1000 parts there were contained :—

Water	958·0
Solid constituents . . .	42·0
Fixed salts . . .	9·4

c. A middle-aged woman with considerable œdema.

The urine was diminished in quantity, was of a dull yellow colour, turbid, faintly acid, and of specific gravity 1017. It deposited a sediment consisting of numerous epithelium scales and cylinders, albuminous fungi, and a few uric-acid crystals. The urine contained a large amount of albumen, which when precipitated by nitric acid had a faintly violet tint, indicating the presence of uroxanthin. The urea, uric acid, and salts were much diminished; the latter amounting to no more than 3 in 1000 parts of urine. Of the various constituents of the saline residue the chloride of sodium was the most diminished.

d. The urine of a patient with considerable œdema, was analysed. It was of a faint yellow colour, turbid, acid, with a specific gravity of 1006, and deposited a slight sediment of pavement epithelium, cylinders, mucus-corpuscles, albuminous fungi, and a few crystals of uric acid.

In 1000 parts there were contained:

Water	985·2
Solid constituents	14·8
Organic matter	13·6
Fixed salts	1·2 containing hardly a trace of chloride of sodium.

e. A patient aged 28 years, who first exhibited symptoms of Bright's disease while in the hospital, in consequence of a broken arm from a fall. The spinal cord likewise appeared somewhat injured by the accident.

The urine was much diminished in quantity, scarcely amounting to twelve ounces in the twenty-four hours; it was of a bluish green (or very deep bottle-green) colour, turbid, and deposited after a short time a flocculent light-blue sediment. After standing for a longer period, a dark blue sediment was gradually thrown down, while the supernatant fluid was yellow.

The surface of the urine was covered with a stiff film of uroglaucin, which presented a beautiful copper-like brilliancy when the light fell on it. With refracted light it appeared of a dark-blue colour, and arranged in stellar groups. The sediment, when examined under the microscope, was found to consist of a great quantity of albuminous fungi and minute crystals of ammoniaco-magnesian phosphate, together with groups of uroglaucin, more or less crystalline in structure, and of a magnificent blue colour: a peculiar modification of pavement epithelium was likewise observed,—oval or nearly circular, with large nuclei and nucleolar corpuscles, frequently arranged in groups; and lastly, cylinders with a little pus.

The reaction of the urine was strongly alkaline, and its specific gravity 1013.

On the addition of nitric acid the urine became of a clear blue colour, and albumen with a violet tint was precipitated, which on standing became of a darker blue, while the supernatant fluid assumed a yellowish hyacinthine colour.

Alcohol slowly added, so as to form a layer on the surface, took up an azure colouring matter. On thoroughly mixing the alcohol with the urine, albumen with a beautiful blue tint was precipitated, while the fluid remained of a hyacinthine colour.

Ammonia communicated a brown colour to the urine.

On the addition of a salt of silver to the acidulated urine there was no precipitation of chloride of silver, but when added to neutralized urine a coffee-coloured tint was developed, indicative of uroxanthin.

On the addition of a salt of baryta there was a slight violet-colour precipitate of sulphate of baryta.

On evaporating the urine there was left a residue of a dark-blue colour, and bright blue spots were observed on the edges of the capsule. It was washed with water, in order to separate the urea, and then extracted with cold spirit of 0·830, which dissolved the urrhodin, and formed a carmine solution. On boiling the residue with spirit, a solution of uroglaucin was obtained, which, on cooling, formed beautiful ultramarine-blue crystals.

The amount of urea was very small, and there was no uric acid or chloride of sodium; on the other hand, there was a large quantity of carbonate of ammonia, and a moderate amount of albumen. The earthy phosphates, phosphate of soda, and sulphate of potash were present in very diminished quantities. Uroglaucin and urrhodin were present to a large amount.

The urine passed on the following morning (amounting to a little above two ounces) was submitted to analysis. It was of a bottle-green colour, turbid, and deposited a sediment which, when examined under the microscope, was found to contain crystals of uroglaucin, and indeed all the constituents noticed the preceding day.

The urine was strongly alkaline, emitting an urinous ammoniacal odour. The specific gravity was 1013, and the reactions, with nitric acid, alcohol, &c., the same as before. There was, however, a larger amount of albumen. Uroglaucin and urrhodin were likewise present in abundance.

The urine contained in 1000 parts :

Water	971·20
Solid constituents	28·80
Urea	3·81
Uric acid	no trace
Fixed salts	3·80
Uroglaucin, urrhodin, uroxanthin, extractive matters, and carbonate of ammonia	14·30
Albumen	9·89

Chloride of sodium was altogether absent; the other salts were diminished in nearly similar proportions.

Death occurred the same evening, about six o'clock. Shortly before that event, nearly two ounces of urine were removed by the catheter. The secretion had lost its previous colour, and was of a deep citron-yellow tint; it was turbid, and deposited a perfectly white sediment, composed of all the previous ingredients with the exception of uroglaucin. It was acid, and remained so for twenty-four hours, although exposed during part of that time to the sun's rays. Its specific gravity was 1012.

From the examination of the urine it seems clear that the uroglaucin and urrhodin are products of oxidation of the peculiar yellow pigment—uroxanthin. For the 'native' urine was intensely yellow, and did not contain, either in solution or in the sediment, a trace of either uroglaucin or urrhodin. On the addition of nitric acid there was a white precipitate of albumen, which gradually assumed a violet tint, and after standing for some time became of a deep blue colour. On the addition of this acid the urine became first of a carmine tint, then of a violet colour, and ultimately of a rich blue; and during these changes it deposited uroglaucin presenting the appearance of bright powdered ultramarine, but under the microscope exhibiting a crystalline form. On the surface of this urine there was formed the same coppery film that was noticed on the blue urine, and the microscope detected crystals of uroglaucin in it. Cold spirit, when added to the sediment, took up urrhodin, assuming a brilliant carmine tint.

Hence it seems to follow that the acid urine, which was of a pure yellow colour, contained uroxanthin, and that this uroxanthin, under the oxydizing influence of nitric acid, yielded uroglaucin and urrhodin in the same manner that it had spontaneously done in the case of the bluish-green specimens. To confirm this opinion a portion of the yellow urine was exposed for a length of time to the action of the atmosphere. The same products were slowly developed which had been rapidly produced by nitric acid. The same red metallic film was produced, the same blue tint gradually developed, and, subsequently, the same blue sediment yielding uroglaucin and urrhodin, while the supernatant fluid became pale.

The urine contained albumen, an extremely small quantity of urea, and not a trace of either uric or hippuric acid. Hence the acid reaction could not depend (as Liebig supposes) on those acids, and Heller believes that "the acid reaction of this urine, and, indeed, of the urine in Bright's disease generally, (where uroxanthin is always present in large quantity,) and most probably of the normal secretion, (at least in part,) is dependent on uroxanthin, which comports itself as an acid, being precipitable by metallic salts."

The body was examined two days after death. A small quantity of urine, amounting to hardly a drachm, was found in the bladder. It had much the same properties as the urine removed by the catheter before death: it had the same acid reaction, and the same yellow colour. It deposited a copious sediment, consisting for the most part of pavement epithelium, and the characteristic cylinders; it likewise contained mucus-corpuscles and oil-globules. The urine contained uroxanthin, but not a trace of uroglaucin or urrhodin, which were, however, subsequently obtained, both by nitric acid and by exposure to the atmosphere.

f. A man under the care of Dr. Seibert. The disease was of considerable standing, and had assumed a chronic form. There was much œdema of the feet, extending to the body, and the secretion of urine was diminished. The urine was of a pale wine-yellow colour, turbid, and threw down a slight deposit consisting of pavement epithelium, cylinders, mucus-corpuscles, and crystals of ammoniaco-magnesian phosphate.

It was faintly alkaline and rapidly developed ammonia; its specific gravity was 1014. Nitric and hydrochloric acids communicated a reddish violet tint to it. After a time albumen with a violet tint was precipitated; hence the urine contained uroxanthin.

In 1000 parts there were contained:

Water	969·25
Solid constituents	30·75
Urea	2·50
Uric acid	0·60
Albumen	6·25
Extractive matters, uroxanthin, and carbonate of ammonia	17·70
Fixed salts	3·50

The fixed salts consisted for the most part of phosphate of

soda; they contained mere traces of chloride of sodium, and a very small amount of earthy phosphates and sulphates.

g. A woman aged 30 years, an analysis of whose blood is given in p. 515.

The urine, on the day on which venesection was performed, was tolerably copious, but had been scanty for some days previously. It was of a faint clay-yellow colour, and threw down a flocculent precipitate consisting of pavement epithelium, very long cylinders, mucus- and pus-corpuscles for the most part containing two distinct nuclei, albuminous fungi, a few fat-globules and blood-corpuscles, and a very few minute crystals of uric acid. The reaction of the urine was strongly acid, and its specific gravity 1017. After the removal of the albumen the specific gravity fell to 1013; there was consequently a considerable quantity of albumen present, and with it a proportionate amount of uroxanthin.

The urea was much diminished.

The uric acid was increased, which is always the case in the early stages, and as long as the disease retains the acute form.

The phosphate of soda and sulphates were apparently unaffected; there were mere traces of earthy phosphates, and chloride of sodium was almost entirely absent.

The urine likewise contained hæmatin in solution, which communicated a brown tint to the fluid, and especially to the albumen on drying.

On the following day the urine and its sediment presented similar characters. The specific gravity was 1012, and after the removal of the albumen 1010.

In 1000 parts there were contained:

Water	973·74
Solid constituents	26·26
Urea	6·48
Uric acid	0·70
Albumen	6·03
Fixed salts	5·05
Extractive and colouring matter	8·00

h. A man aged 20 years, who had been for a long time under the care of Dr. Bittner. The disease had assumed the chronic form, and there was great general œdema.

The urine was turbid, of a very pale yellow colour, and de-

posited a trifling sediment, composed for the most part of albuminous fungi, cylinders, and pavement epithelium with a few mucus-corpuscles.

The urine was faintly acid, but in the course of thirty-six hours became alkaline. The specific gravity was 1009. It did not contain much albumen, and only a very little uroxanthin. In 1000 parts there were contained:

Water	978·5
Solid constituents	21·5
Urea	2·5
Uric acid	traces
Albumen	4·6
Extractive and colouring matters	9·4
Fixed salts	5·0

On a further examination of the salts it was found that the chloride of sodium was extremely diminished.

The urine was examined on two separate occasions, some days later, in relation to the solid constituents generally and to the albumen. There were found:

	1.	2.
Water	978·6	978·2
Solid constituents	21·4	21·7
Albumen	4·5	4·5

Hence in these respects it had remained constant.

Some weeks later, and very shortly before the patient's death, the urine was again examined. It was red from the presence of blood, had a putrid odour, and deposited a sediment, which, in addition to the ordinary constituents, contained numerous blood- and mucus-corpuscles, undoubted pus-globules, and a little uric acid. The reaction was acid, and the specific gravity 1010. A considerable amount of uroxanthin was present. In 1000 parts there were contained:

Water	976·23
Solid constituents	23·77
Urea	1·76
Uric acid	0·24
Albumen with a little hæmatoglobulin	8·75
Extractive and colouring matters	8·54
Fixed salts	4·48

The chloride of sodium was much diminished.

Hence we see that blood occurs in the urine, not only in

the early stages but likewise towards the close of the disease. In the former case it arises from congestion, in the latter it is a consequence of incipient dissolution.

i. A woman aged 40 years, with much œdema, under the care of Dr. Sterz.

The urine, in this case, was very remarkable for its extremely high specific gravity, dependent on an enormous amount of albumen. The secretion was very much diminished. The urine was of a clay-yellow colour, turbid, and formed a tolerably abundant sediment, containing numerous cylinders and mucus-corpuscles, together with urate of ammonia. There were also a few granular cells (Gluge's inflammatory globules) and numerous albuminous fungi.

The reaction of the urine was acid. Nitric acid caused a dense coagulation of albumen, which rapidly assumed a violet tint; hence a tolerably large amount of uroxanthin was likewise present. The specific gravity was 1047.

In 1000 parts there were contained:

Water	860
Solid constituents	140
Albumen	57

The urine retained these characters for a considerable time, always holding hæmatin in solution. It subsequently became less dense, as the disease assumed a chronic character.

k. A girl aged ten years: œdema general and well-marked. The urine was very pale, and of a dirty clay-yellow colour; a little fluid fat separated on the surface. There was a very slight deposit of epithelium and albuminous fungi. Reaction faintly acid; specific gravity 1005. A small quantity of albumen was present, which, on being precipitated by nitric acid, rapidly assumed a violet tint; on the addition of hydrochloric acid the urine was rendered turbid, and likewise became of a violet colour; a relatively increased quantity of uric acid was thus separated, and the crystals were of a beautiful deep blue tint. Hence, notwithstanding the low specific gravity, the urine contained a large amount of uroxanthin. Of urea there were only traces, and the salts were diminished to an extreme degree; the phosphate of soda—the principal ingredient—being far below the average, the sulphates and chloride of sodium very trifling,

while there was a mere trace of earthy phosphates. The subsequent dissection confirmed the accuracy of the diagnosis.

l. An aged man, under the care of Dr. Folwaczny. The urine was extremely turbid, of a dark clay colour, and formed a sediment without itself becoming clear. The sediment was composed of albuminous fungi, numerous cylinders, pavement epithelium, and urate of ammonia. It was upon the presence of the last ingredient that the turbidity was dependent, for on the application of a gentle warmth the fluid became clear. The reaction was strongly acid, and the specific gravity 1029. After the removal of the albumen the specific gravity was only 1017. Hence a large quantity of that constituent was present. On the addition of nitric acid, albumen with a deep violet tint was precipitated; consequently there was much uroxanthin in the urine. The urea was far below the average; the uric acid and urate of ammonia were abundant. The salts collectively were much diminished, but most especially the chloride of sodium.

The subsequent dissection proved the accuracy of the diagnosis.

From these and five additional cases Heller draws the following conclusions.

He divides the disease into three stages, in all of which the urine presents separate and distinctive characters.

The first is the congestive stage, during which the urine is red from dissolved blood or hæmatin, but at the same time is acid unless neutralized by the presence of very much blood.

In the second—the chronic stage—the urine is pale and of a clay-yellow colour, and frequently resembling whey.

In the stage of dissolution which (frequently but not invariably) shortly precedes death, the urine is ammoniacal, developes a putrid odour, and is again bloody. At this stage the dropsical effusions give off an odour resembling that of rotten eggs.

In all three stages the urine is (with occasional exceptions) diminished. The largest amount is passed during the chronic stage, when the œdema frequently diminishes for a short time. During the first and last stages, the daily amount of urine seldom exceeds a few ounces, and blood is often present.

The following are the physical characters of the urine. In the first stage it is red and turbid, forming either a red or

white sediment, according as blood-corpuscles are or are not present. The urine is acid, neutral, or slightly alkaline, and has a low specific gravity.

In the second stage the urine is of a clay-yellow colour and turbid, forming a brown sediment; subsequently the fluid becomes of a paler colour, of very low specific gravity, and deposits a white flocculent sediment; and at this period it exhibits a greater tendency to putrefaction than before.

In the third stage the urine is of a dark red colour, and contains more or less blood; it also deposits a red or reddish-brown sediment containing numerous blood-corpuscles. It is either ammoniacal on emission, or rapidly becomes so, and its specific gravity is higher than in the other stages.

The occurrence of blood in the first and third stages is dependent on totally different causes.

In the congestive stage the constituents of the blood enter the urine by the law of endosmosis, and it is not so much actual blood as serum reddened by hæmatin in solution that passes over; in the last stages, however, the capillaries are actually corroded by the morbid process, and then the blood-corpuscles likewise find their way freely into the urine. Hence in the latter stage the sediment is always of a reddish-brown tint, while in the former it is often white.

The microscopic appearances are divided by Heller into—1, those of constant occurrence, and 2, those occasionally present.

The constant constituents are:

1. Pavement-epithelium, which is always present, and frequently in the congestive stage forms a copious white sediment.

2. Epithelium from the tubes of Bellini, which usually forms only a slight portion of the sediment in the early stages, although sometimes present in large quantity from the commencement of the disease.

3. Albuminous fungi occurring as a clear dotted granular matter in all fluids containing albumen. When they are very abundant the urine developes a mouldy odour.

4. Mucus-corpuscles.

5. Granular cells (globules of inflammation) are always to be found during the congestive stage.

6. Fat-globules, especially in the chronic form of the disease.

The occasional constituents are:

1. Crystals of uric acid, even when there is a deficiency of that constituent in the urine.
2. Urate of ammonia, generally in the early stages.
3. Pus-corpuscles, usually in the latter stages.
4. Blue crystals of uroglaucin, usually after the urine has stood for some time.
5. Ammoniaco-magnesian phosphate, when the urine contains carbonate of ammonia.

The specific gravity of the urine in this disease is variable; its limits in Heller's cases were 1006 and 1048.

The reaction is usually acid, often strongly so. In some of the cases in which the acidity was most marked, the urine contained neither uric nor hippuric acid.

Albumen (according to Heller) is always present; the quantity is, however, very variable, and is smallest in children.

Uroxanthin is always present in large quantity.

The urea exists in diminished quantity.

The uric acid is at first increased, but subsequently diminishes, and almost disappears.

The salts collectively are much diminished, the diminution corresponding with the progress of the disease. The earthy phosphates and chloride of sodium can sometimes hardly be detected.

We are now enabled to compare the composition of the blood, urine, and dropsical effusions in this form of disease.

From a general view of the preceding analyses, (see pp. 494, 515,) it appears that these fluids are a state of antagonism. The water which is retained in the system in consequence of the partial suppression of urine, does not remain in the blood, but collects in the form of dropsical effusions.

The albumen, which generally occurs in large quantity in the urine, is taken from the blood, which in the way loses a large quantity of this constituent.

This is the way in which most of the albumen is removed, for the subcutaneous dropsical effusions contain very small quantities of it.

When, however, dropsy occurs independently of disease of the kidneys, albumen in large quantity is found in the effusions.

The inorganic salts, which are diminished (or are almost absent) in the urine, do not remain in the blood, but enter the dropsical fluids, where they are often found in an extraordinary quantity.

Finally, the urea which is much diminished in the urine, occurs in large quantity in the blood, and in smaller quantity in the dropsical fluids.

PAGE 362. *Liquor amnii.* The following analyses of the liquor amnii of women ought to have been mentioned. They were made by Colberg.[1]

	1.	2.
Water	980·0	977·0
Solid constituents	20·0	23·0
Albumen	9·0	12·0
Urea	0·5	—
Alcohol-extract and lactates	2·0	3·0
Fat	2·0	3·0
Chloride of sodium	4·0	4·0
Phosphate of lime	0·2	—

[1] Neue Zeitung für Geburtskunde, 14. 1. 1843.

EXPLANATION OF PLATE II.

Fig. 13. Saliva.
13* *A.* Colostrum. *B.* Healthy milk.
14. Epithelium.
15. Nasal mucus.
16. Bronchial mucus, with the corpuscles seen in other forms of mucus.
17. Pus from the lungs.
18. Tubercle.
19. Peculiar forms occurring in tubercle.
20. Pure urea from urine.
21. Nitrate of urea from urine.
22. Oxalate of urea from urine.
23. Various forms of uric-acid crystals.
23* Various forms of hippuric acid.
24. *A.* and *B.* Chloride of sodium as it crystallizes from urine.

EXPLANATION OF PLATE III.

Fig. 25. Phosphate of ammonia and soda from evaporated urine.
26. Phosphate of lime from an urinary sediment. [The foliaceous bodies are most probably urates.]
27. Ammoniaco-magnesian phosphate from an urinary sediment.
28. Various forms of urate of ammonia from urinary sediments.
29. Various forms of urate of soda from urinary sediments.
30. *A.* and *B.* Various forms in which an acid solution of the earthy phosphates is precipitated by ammonia.
30* Carbonate of lime.
31. The sediment occurring in Bright's disease.
32. Cystin.
33. Seminal animalcules and granules.
34. Cholesterin.
35. The torula (the fermentation-globules) in diabetic urine.
36. Oxalate of lime in various forms.
37 and 38. Uroglaucin.


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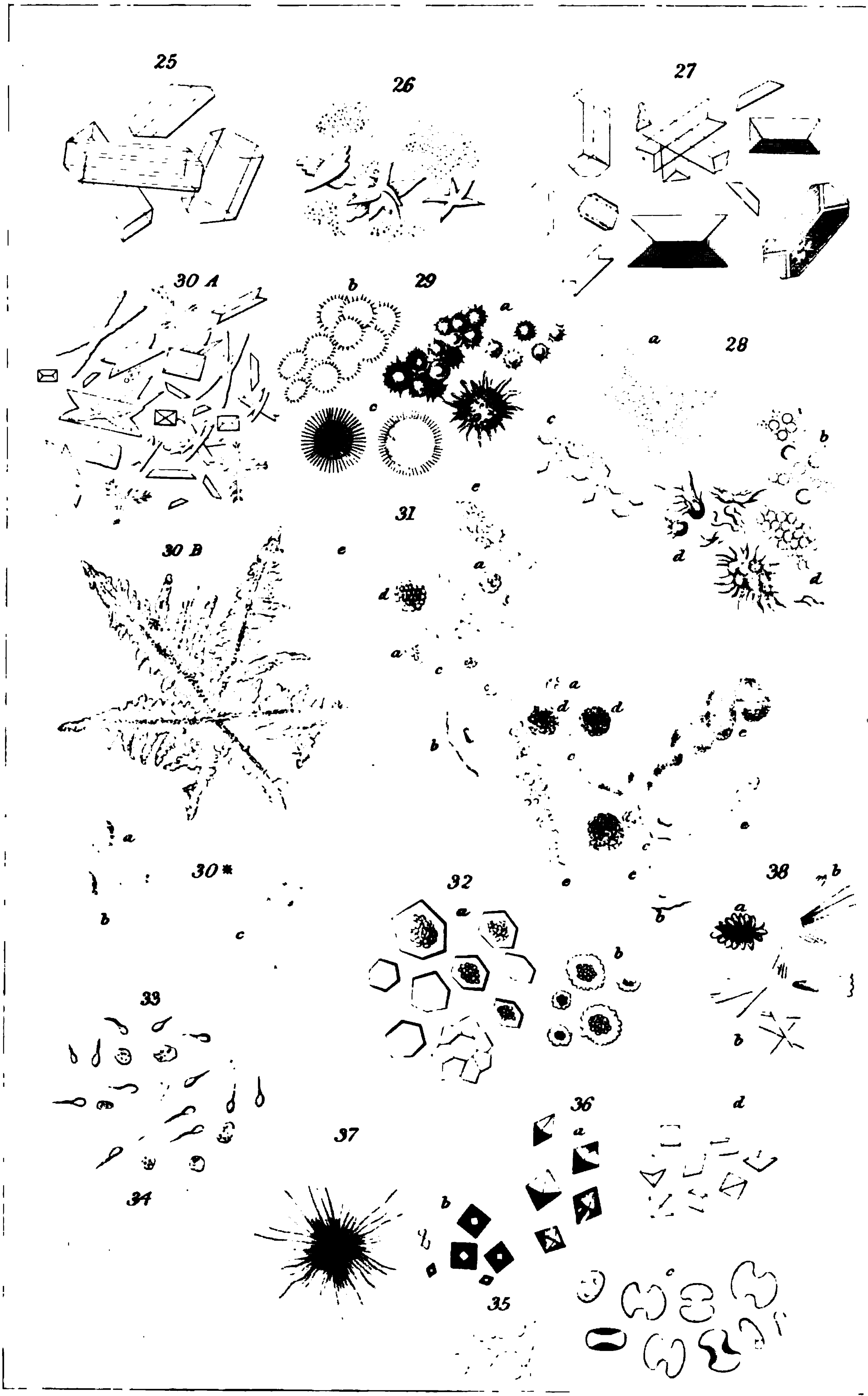
24 A
24 B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THE END.

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